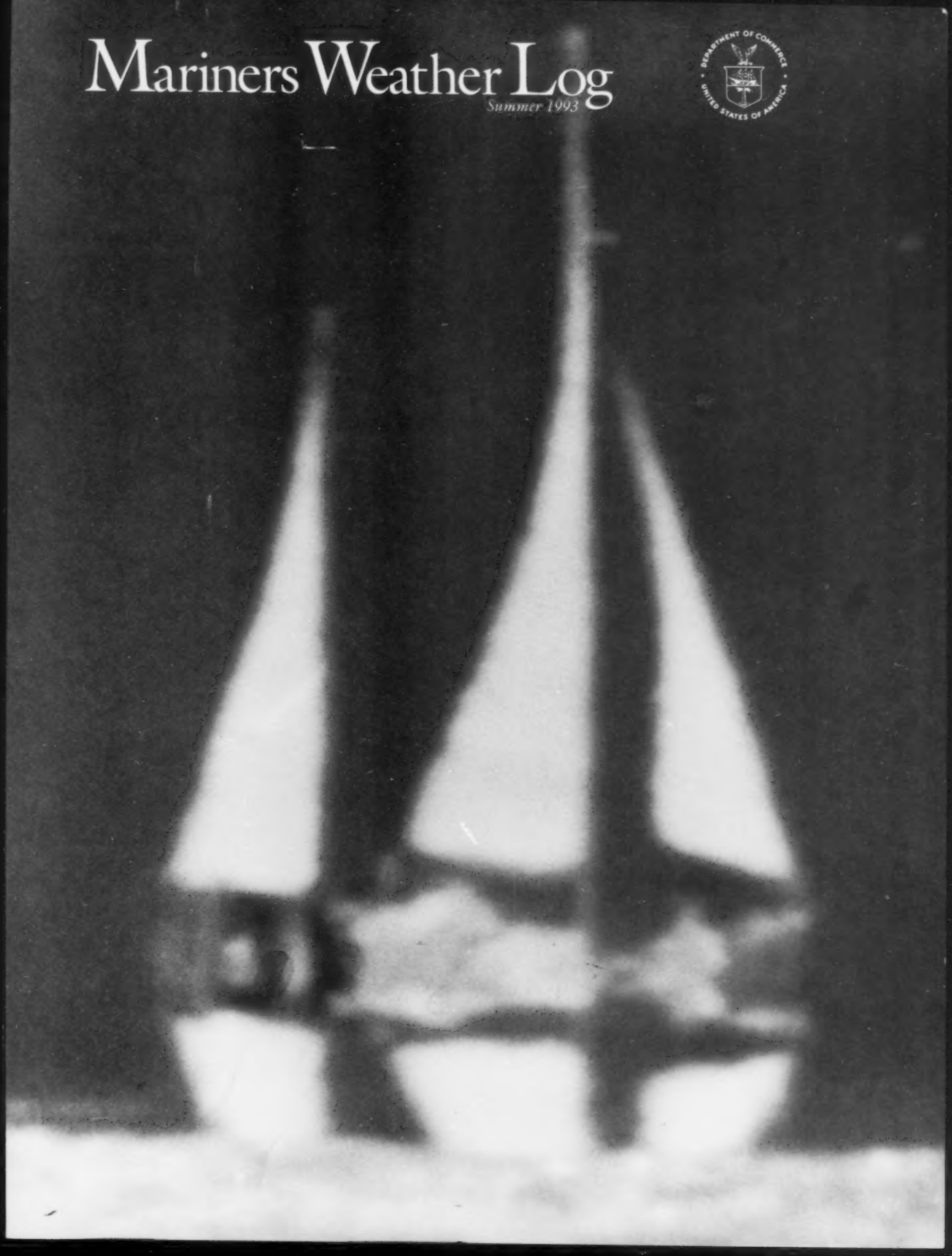
Mariners Weather Log

Summer 1993



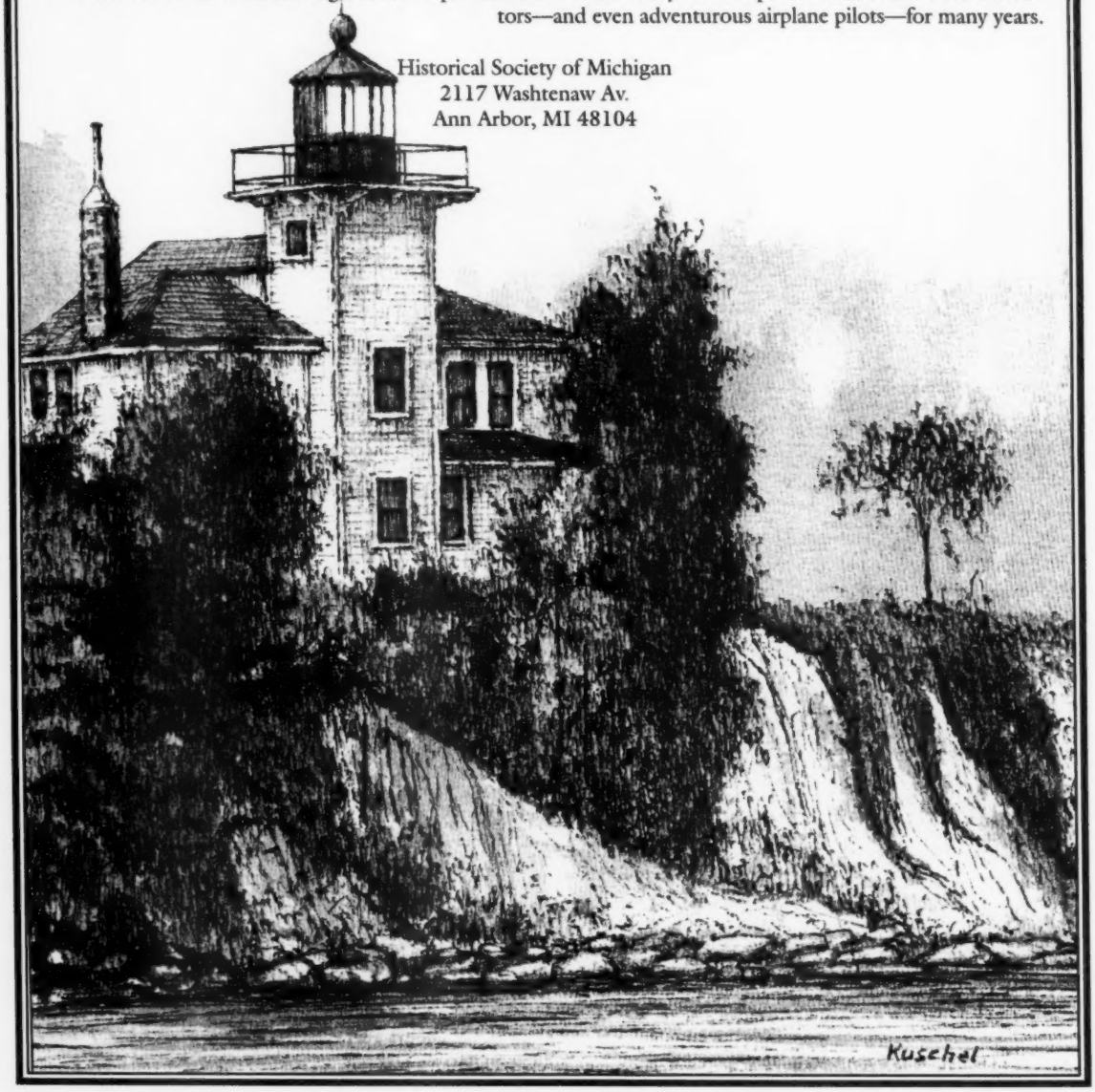
Raspberry Island Lighthouse

Lake Superior
Bayfield, Wisconsin

Pen and Ink Drawing by Leo Kuschel
Descriptive passage by Leo and Sue Kuschel

On the southwest point of Raspberry Island is this tower, 46 feet above ground and 77 feet above water. It was lit from 1862 until 1957, when it was replaced by a pole type light located near the fog signal building. There are many rescue stories told by families stationed here. One took place in 1932 when the keeper noticed that the York Island Shoal Buoy had disappeared. He searched by boat unsuccessfully. A civilian from St. Paul, Minnesota, Walter Wellesch, volunteered to search in his private plane and eventually found it. He received a letter of thanks from the Lighthouse Superintendent. The beauty of the Apostle Islands has attracted visitors—and even adventurous airplane pilots—for many years.

Historical Society of Michigan
2117 Washtenaw Av.
Ann Arbor, MI 48104



Mariners Weather Log

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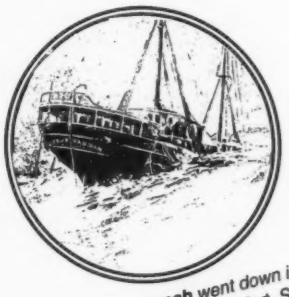

The **City of Savannah** went down in a hurricane 100 years ago off Beaufort, SC. Story on page 67.

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Cover: The photo appears to show a two–masted sailboat and its reflection in the water. However, it is really a two–image mirage. In the upper image the hull has vanished, a common characteristic of the two–image mirage. Photograph taken on Puget Sound by Professor Alistair B. Fraser of Pennsylvania State University. Story on page 4.

Back Cover: Panorama of a roll cloud formation was taken by Dave Morris, Captain of the ***Shenahon***, about 15 miles south of Frankfort, Michigan on the 14th of May 1993. It took two exposures to capture this Lake Michigan scene.

Inside Back Cover: Just off the Naval Base at Portsmouth, VA, Lt. Ross E. Bryant, III, Commanding Officer of the USCGC ***Aquidneck***, was on hand to capture the eerie mood of some thick ground fog which shrouded one of the aircraft carriers and some surface combatants.

Mariners Weather Log

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The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through July l, 1994.

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Corrections

This should probably be an annual feature, but scheduling it becomes a little disheartening. Mistakes, except for *National Geographic*, are part of the game. There are the glaring ones that jump out at you as soon as the new publication arrives, and then there are the ones that only a few people notice either through expertise or because it involves their work. Those are just as frustrating. Somehow a correction in the next issue just isn't the same, but often that's the only choice.

A real odd miscue cropped up in the Buoy Tables last year. For some unknown reason, the January 1992 table contained January 1991 data. You will find the real January 1992 Buoy data in this issue along with the real January 1993 data. In the past issue, several unfortunate mistakes were made. The most important was an accidental switching of the credits for the photographs in the Channel Islands article. The Channel Islands photograph was taken by William B. Dewey while the Playful Dolphin was taken by Dean DePhillipo. I hate this kind of mistake because it is very important to the artists involved. Both were fine photographs and I hope the photographers understand. Similiarly, but less disastrous, was the photograph of Point Cabrillo (which should really be pronounced as the Spanish Cabreeyo) on page 33, which in actuality is the Lighthouse at Cabrillo National Monument, San Diego (which is pronounced with an *ill* sound) and is called Old Point Loma Lighthouse. Elinor De Wire noticed it right away, but unfortunately she hadn't seen the photograph we were using. My apologies to all those involved, and we will alter some of our present practices to keep those errors to a minimum. Years ago we carried the Marine Weather Dairy for several issues before someone pointed out that it should be Marine Weather Diary.

William B. Dewey

Dean DePhillipo

The Newark Bay– A U.S. VOS Ship

MARINE MIRAGES

ADRIENNE MAYOR

Since at least the time of the Crusades, Mediterranean sailors have described a fantastic panorama of towers, arches, and castles shimmering in the sea's mist between Italy and Sicily. These fabulous mirages are called *Fata Morgana* because the Crusaders imagined they were the handiwork of Morgan le Fay, the enchantress of Arthurian romance.

Morgan, said to live in an undersea palace off southern Italy, was famous for creating "castles in the air." According to medieval legend, seafarers who mistook her magical mirages for a safe harbor were led far off course and hopelessly lost. A typical account written in about 1500 describes "an array of towers, pinnacles, and columns, palaces with balconies and windows, extended alleys with trees...a scene of architectural magnificence" hovering above the horizon until it seems to slowly melt away.

In 1634 in Reggio di Calabria, a port on the tip of Italy's toe, a priest, Father Angelucci, gazed out over the Strait of Messina toward Sicily to see what he called a"vision of paradise." He strove to describe it scientifically in a letter to his friend Athanasius Kircher, a German archaeologist and physicist.

*The **Rime of the Ancient Mariner** was wonderfully illustrated by Gustav Doré. Here the ghost ship is entering the Antarctic wonderland as Coleridge describes: "And now came both mist and snow, / And it grew wondrous cold: / And ice, mast high, came floating by, / As green as emerald. And through the drifts the snowy clifts / did send a dismal sheen:/ Nor shapes of men nor beasts we ken– / The ice was all between."*

"The ocean which washes the coast of Sicily rose up and looked like a dark mountain range;" against this backdrop "quickly appeared a series of more than 10,000 whitish-gray pilasters" which "then shrank to half their height" and were transformed into "arches like those of Roman aqueduct." Then the vision shimmered and disappeared.

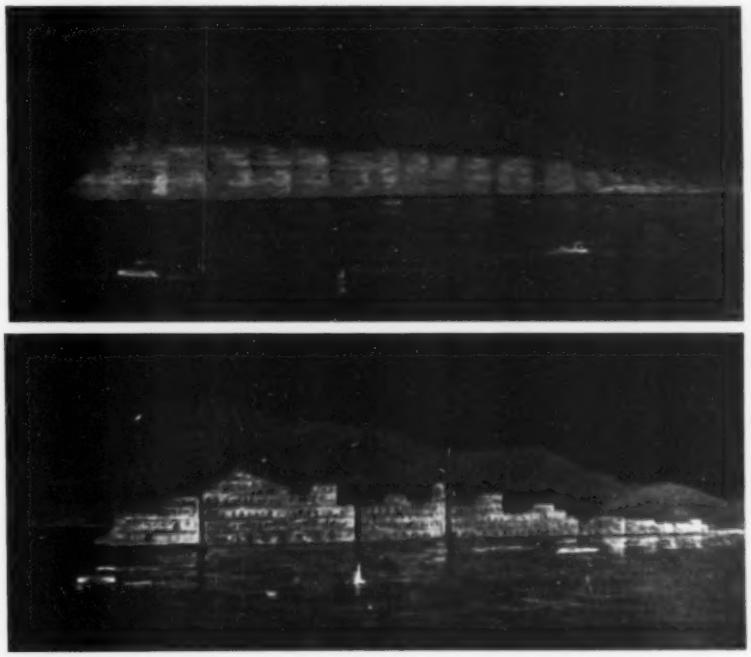
Kircher, intrigued by the phenomenon, attempted to reproduce the ocean illusion in his laboratory by passing a ray of light through a heated vessel fashioned to mimic the shape of the Strait and containing sand from Sicily. Encouraged by the partial success of this experiment, Kircher was ultimately able to project a mirage effect on a screen that terrified and mystified audiences. Kircher is credited with the invention of the magic lantern, the precursor of motion pictures—and inspired by optical illusions at sea.

About a century after Angelucci's experience, a Dominican friar named Minasi published a dissertation on ocean mirages after witnessing the *Fata Morgana* three times. At sunrise, he writes in 1773, when the sea is calm the spectator, with the sun behind him and facing the sea, may suddenly see "various multiplied objects, such as numberless series of pilasters, arches, castles well delineated, columns, lofty towers, superb palaces with balconies and windows."

While Minasi's description seems to parallel Angelucci's, eighteenth century mirage-watchers tended to invest their visions with action-packed details. Besides cattle and sheep grazing in "delightful plains," Minasi saw "armies of men on foot and horseback, and many other strange figures all in their natural colors and proper action, and passing rapidly in succession along the surface of the sea."

Although marine mirages were sighted elsewhere, the *Fata Morgana* of the Strait was considered the classic example. A drawing included in Minasi's treatise became the standard textbook representation of an ocean mirage.

A 1912 article in *Scientific American* predicted that one should be able to obtain "good photographs of Fata Morgana...without difficulty." By 1975, specialists in meteorological optics had successfully predicted and photographed a variety of marine mirages. Meteorologist Alistair Fraser determined the necessary atmospheric conditions, predicted, and then photographed several mirages in Puget Sound (cover). According to Fraser, when the flat, evenly lighted surface of the sea is warmer than the air above, the air acts as a magnifying glass distorting real features of the landscape or a boat into what appears as a mist or fog. Then gentle breezes "sculpt" the blurred image into spectacular castles, cities, mountains, or fancy bridges



There have been many eyewitness accounts and discussions of the atmospheric details of Italy's great illusionary metropolis. Early in the twentieth century, a physicist from Reggio di Calabria, V.E. Boccara, made three sketches of the illusion. The first (upper) depicts the eerie streak of white mist that often heralds the phantom city rising out of the sea against a magnified backdrop of mountains. The second (lower) is the fully developed Fata Morgana in all its glory. The third illustration (page 6) shows a three-tiered cityscape suspended over the water. From ***Scientific American****, 106 no. 15 (April 13, 1912).*

Adrienne Mayor is a free-lance writer and editor who has written for *Sea Frontiers* and *Popular Science Annual* among many magazines. Her ocean-oriented work includes dolphin folklore, inexplicable phenomena observed at sea, ancient Greek and Roman shipwrecks, mermaids, monsters, and Mediterranean wind lore.

This article first appeared in the January-February 1988 issue of *Sea Frontiers*. This is a publication of the *International Oceanographic Foundation/North America* located at 4600 Rickenbacker Causeway, Miami, FL 33149.

of the type so ornately described by the Italians.

Particularly fanciful descriptions characterize the Irish tales of ocean mirages, called "fairy isles" or "fairy castles." As in the Morgan le Fay legend, they were said to be responsible for beckoning sailors to misadventure.

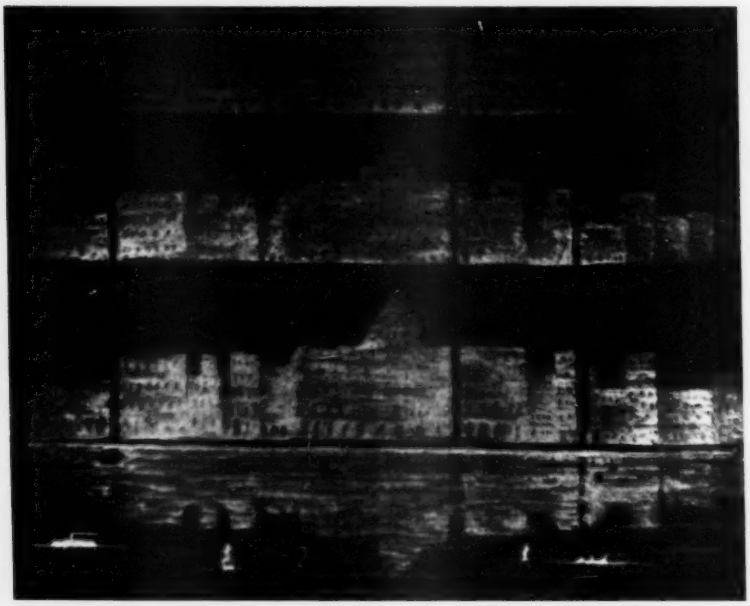
In the late seventeenth century, historian Roderick O'Flaherty recorded that to inhabitants of the island of Arran in the Firth of Clyde, northeast of Ireland, "often appears visible that enchanted island, called O'Branil, and in Irish Beg-ara." The chronicler describes the place as a "wild island of huge rocks" that occasionally rises in the sea. At times one could also see a "great city far off, full of houses, castles, towers, and chimneys. Suddenly the mirage would become an animated cavalcade of "blazing flames, smoke, and people running to and fro." At other times, one saw "nothing but a number of ships, with their sails and riggings suspended over the ocean. Sometimes, seamen were treated to sights of lively fairs in progress; others saw great bridges spanning the sky over the sea; one fairy island was more mundanely populated by women busily hanging out laundry. In the early summer of 1871, over the Firth of Forth (along the east coast of Scotland), "scarcely a day passed without several instances of atmospheric phenomena of vivid and interesting character." The "extraordinary optical illusions" over the sea were reported in great detail in the sober pages of *Symon's Monthly Meteorological Magazine.* The most spectacular display occurred on a warm Saturday afternoon.

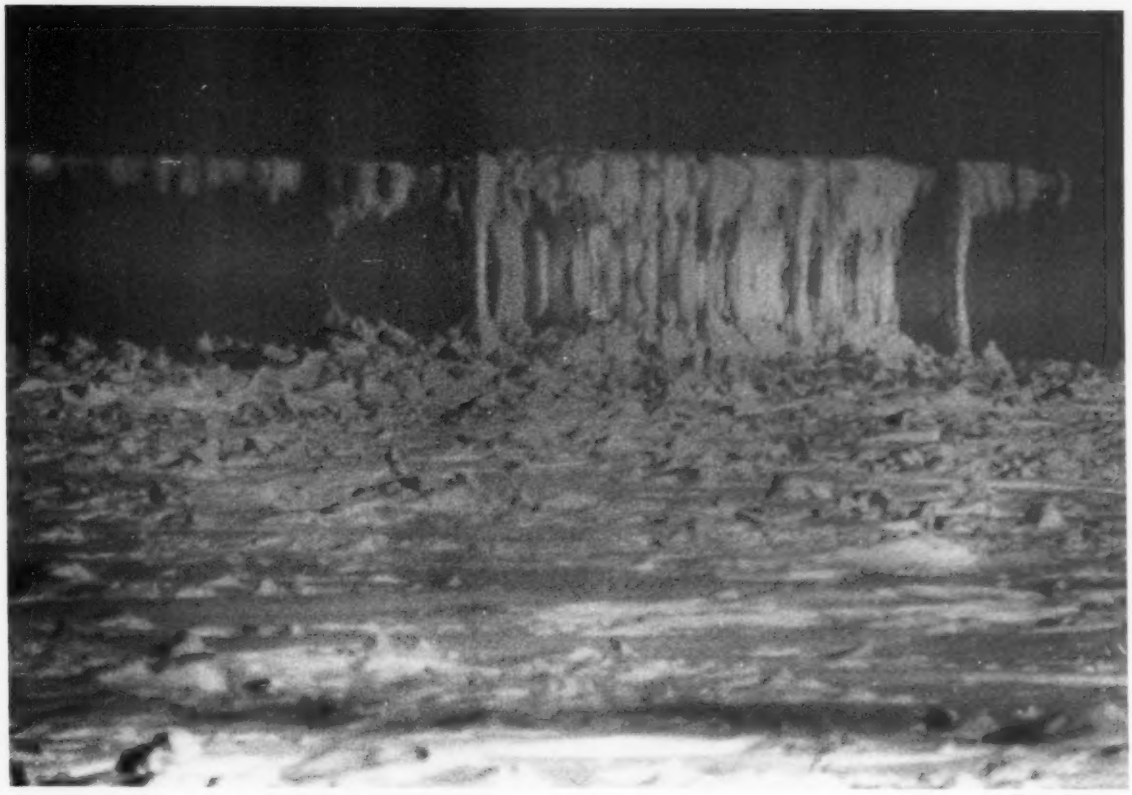
First an image of Balconic Castle on the Fife coast appeared about 45 degrees up from the horizon. Tiny May Island "suddenly shot up in the form of a huge perpendicular wall, apparently 800 or 900 feet high" A long row of rocks east of the island "assumed the most diversified and fantastic shapes"; once they appeared as a "beautiful columnar circle, 20 to 30 feet high," then they changed to a grove of trees which rapidly expanded to a "plantation." An arch spanned the trees and the island, then dozens more arches appeared in quick succession; meanwhile "jagged rifts and ravines" opened in the face of the high wall and a series of towers, columns, and archways sprang up and disappeared. Astounded witnesses watched this incredibly active panorama for 4 hours; the show ended when the island shrank to a thin blue line above the horizon and a drenching rain began.

The 1914 *Royal Meteorological Society Quarterly Journal* carried an account of a mirage that appeared off the Cornish coast near Land's End, England. Along the sea horizon suddenly appeared a line of coastal scenery, complete with woods, fields, and hedges. Before long the witness recognized the scene as a reflection of his own location– he was able to identify several church spires, a river, and the harbor of Falmouth. Soon he saw Pendennis Head with its castle and military buildings. The mirage lasted for several minutes and was "reversed as in a looking glass and slightly magnified."

French legend tells of another ancient submarine city, Ys, which can be glimpsed in the Bay of Douarnenez. This mirage has an aural facet–some travelers say they can hear the tolling church bells of Ys. Some legends of cities that appear to be submerged below the sea could be inspired by what Minasi had classified as "marine" (as opposed to "aerial") mirages. In modern terminology, the cities beneath the sea correspond to "sinking" inferior (as opposed to superior) mirages. These refractions occur when the temperature decreases in relation to the height above the ocean surface.

Landscapes shimmering over the sea have inspired poets–in a famous verse by Wordsworth a spectacular city with "alabaster domes and silver spires" and "bright pavilions" appears in the sky; "towers with battlements" and "terraces upon terraces" are repeat-





Robert Greenler

Not really there, a distant wall of ice forms an Arctic Fata Morgana mirage. The photograph was taken by Professor Robert Greenler of the University of Wisconsin–Madison. Where the illusory wall loses touch with the ground, it floats like an ice castle in the sky. A temperature inversion, with a layer of warm air above colder air, bends light rays to create looming mirages. Pinnacles, columns, and spires can appear to rise up from the almost flat terrain.

ed endlessly and constantly transformed upon the screen of clouds until the "vapors recede" and the scene vanishes. Wordsworth's romantic description is remarkably like Father Angelucci's dramatic vision.

Most of the supernatural images in the poetry of Samuel Coleridge were mirage– inspired. Coleridge was an avid reader of the memoirs of the early polar explorers, who often encountered mirages. In one of his verses, a mysterious island appears over the sea, its "o'er–hanging cliffs glassed in the oceans," and "warriors coursed o'er the sky and battle din mid–air." And in Xanadu of "Kubla Khan" "high in the air a stately palace rose...the shadow of the dome of pleasure floated midway on the waves ... a miracle of rare device/a sunny pleasure dome of ice!" The surreal images of green ice floes, the desolate spires of icebergs, and the dazzling mirages described by the explorers inspired the polar setting, celestial visions, and the ghost ship described in the "Rime of the Ancient Mariner" (1798).

In the lonely and vast seas of the Arctic and Antarctic, mirages are common. The dry, dust–free air makes it possible to see for miles, so distances are deceptive. Due to complex atmospheric conditions, the ocean sometimes appears concave, bending upward toward the horizon. In a type of superior mirage that occurs when the air temperature increases with height above the surface, land masses, icebergs, or ice fields beyond the horizon seem to loom ominously near, or a mountain range far inland may suddenly appear to be on the coast, spectacularly magnified with distinct features.

These *magnifications* or *looming* mirages have been recorded in ships' logs around the globe. The *Marine Observer* of 1938 reported that on a regular run of the ship ***Hauraki*** from Suva to Papeete in the South Pacific, Tahiti appeared to be only 35 miles away– in fact, it was 250 miles distant. The next year the captain of the ***Morrissey*** traveling between

Greenland and Iceland saw clearly recognizable mountains and landmarks of Iceland which appeared to be only 30 miles off, when they were actually 300 miles away.

In 1818 the British explorer Captain John Ross, searching for the Northwest Passage to China, was defeated by a polar mirage. Sailing up Lancaster Sound, the actual entrance to the Northwest Passage, on his lead ship, ***Isabella,*** he saw the entire end of the sound blocked by a formidable mountain chain, which he named the Croker Mountains. Dismayed by what was actually the realistic mirage of a continuous land mass, he abandoned his search for a passage to the Pacific.

Probably the most famous geographic delusions orchestrated by an Arctic mirage is the case of Robert E. Peary's Crocker Land, "discovered" in 1906. Trying to reach the North Pole, Peary saw a spectacular expanse of snow-capped mountains, valleys, and hills, which he judged to be about 120 miles west of his vantage point on the northern tip of Axel Heiberg Land. He again observed the same "land" from Cape Columbia on Ellesmere Island and mapped it at about 83°N, 103°W. Despite his Arctic experience, even Peary was not immune to the sorcery of the mirage and the yearning it aroused. He wrote that as he gazed at the beautiful "snow-clad summits above the ice horizon," his "heart leaped the intervening miles of ice." He looked "longingly at this land, and, in fancy, I trod its shores and climbed its summits, even though I knew that that pleasure could be only for another in another season."

Not until 1914 was Peary's error revealed. Financed by the American Museum of Natural History, a party led by Donald B. MacMillan set out in 1913 to explore Crocker Land with sledges and dog teams. MacMillan and Fitzhugh Green set off from Cape Thomas Hubbard over the polar seas made treacherous by blowing snow, "stretching and bucking" thin blue ice, and temperatures of –25°F. At last, "this morning Green yelled in through our igloo door that Crocker Land was in sight," wrote MacMillan in his diary. "We all rushed out...Sure enough! There it was as plain as day– hills, valleys, and ice cap, a tremendous land extending through 150 degrees of the horizon." MacMillan crowed,"Great Heavens, what a land!"

The group pressed on, catching tantalizing glimpses through fog and blowing snow of the "mountain range glittering in the sunshine." After 7 days they calculated that they had gone at least 137 miles over the polar seas, far beyond where Crocker Land should have been. MacMillan scanned the horizon with binoculars– the sky was now "a deep cloudless blue and all the mist had disappeared." No land was in sight. They had been pursuing a hyperborean looming mirage.

Some historians suggest that *looming* and *magnification* mirages may actually have helped ancient sea explorers to discover lands that lay beyond the true horizon, enabling them to see over the curve of the earth and use islands as stepping stones across unknown seas.

Optical illusions at sea appear to be based on recognized mirage phenomena: fairy islands or celestial castles that appear and disappear to tantalize homesick sailors, and ghostly ships sailing the skies could be attributed to looming superior mirages, and kingdoms in the sea to inferior mirages.

Mirages at sea have enchanted ocean voyagers, inspired poets and legends, and sparked the curiosity of scientists. The editors of the *Journal of the Optical Society of America* claim that scientists who study meteorological illusions are really "natural philosophers" lured by the "intrinsic fascination" of the mirage, a phenomenon that will continue to bewitch anyone who gazes out over a still sea on a hot summer morning.

FOR FURTHER READING

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A public service message from:
The Center for Marine Conservation
The National Oceanic and Atmospheric Administration
The Society of the Plastics Industry

This high-resolution visible satellite picture shows the northeast part of Hurricane Darby's eyewall crossing over Socorro Island at 2301 UTC on the 5th of July 1992. Observations from that island, and from the ***Oasis*** *in the vicinity of nearby San Benedicto Island, indicate that Darby had maximum sustained wind speeds near 100 knots at this time.*

Eastern North Pacific Hurricanes —1992

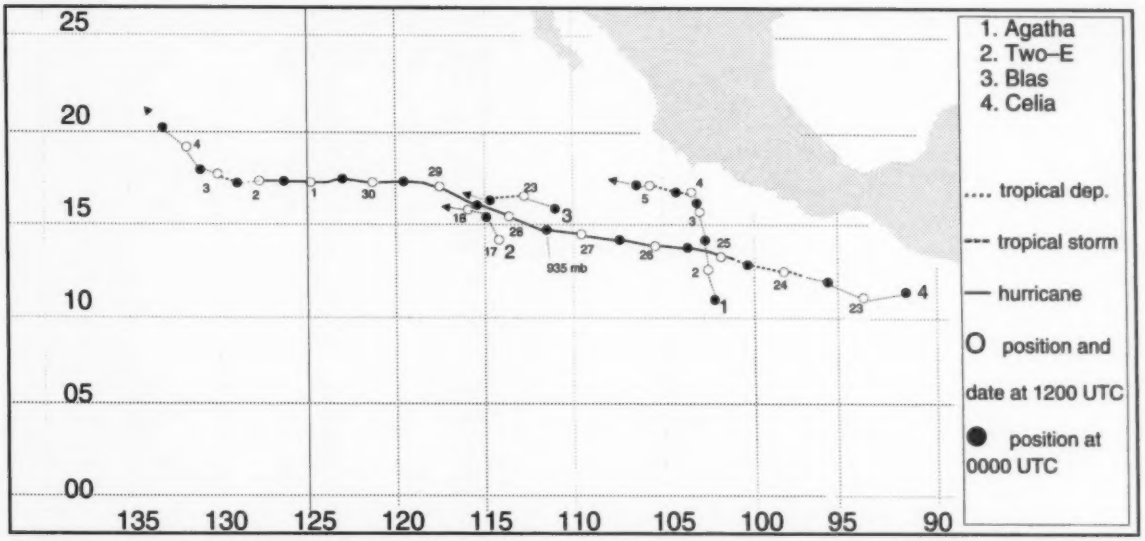
Edward N. Rappaport and Miles B. Lawrence
National Hurricane Center

Numerous challenges confronted eastern North Pacific mariners during the 1992 hurricane season. A record 27 tropical cyclones menaced the area, breaking the previous record of 26 set in 1982. Twenty-four reached tropical storm strength 14 attained hurricane status (5 more than average). Nine of these became major hurricanes (estimated 1-minute surface wind speeds exceeding 95 knots). Hurricane Tina set an endurance record for North Pacific tropical cyclones of 24 days. The previous record was 22 days, held by Typhoon Rita in 1972.

Most of the cyclones formed to the south or southwest of Mexico and many approximately followed climatology, heading toward the west northwest. There were notable exceptions, however. Tina, for example, made two sharp turns early in its life and later underwent a more gradual turn of nearly 90 degrees.

Nine tropical cyclones crossed 140°W longitude, which is the boundary separating the eastern and central North Pacific hurricane basins. One of those systems, Tropical Depression Eighteen- E, eventually became Hurricane Iniki in the central Pacific. Iniki was the first tropical cyclone on record to strike the Hawaiian Islands as a major hurricane. On the 11th of

Ed Rappaport and Miles Lawrence are Hurricane Specialists at the National Hurricane Center in Miami, FL. Also making significant contributions to this report were Lixion Avila, Hal Gerrish, Max Mayfield, and Richard Pasch from the National Hurricane Center.



September, it made landfall on the south coast of Kauai with a central pressure of 945 millibars and an estimated maximum sustained wind speed of 110 knots. Iniki killed three people in Hawaii, and with total damage estimated at $1.8 billion, is the costliest hurricane in Hawaiian history.

... NHC received 40 ship reports of tropical storm or hurricane conditions this year, all from east of 120°W longitude.

Other storms remained nearer the west coast of Mexico where Lester, Virgil, and Winifred, made landfall. In less than 1 week, both Virgil and Winifred came ashore just southeast of Manzanillo, Mexico as category 2 hurricanes on the Saffir/Simpson Hurricane Scale. In total, eastern Pacific tropical cyclones were responsible for six deaths in Mexico. Five other people were reported missing along the southwest coast of Mexico.

With such an active season in the eastern Pacific, and with several of the cyclones developing in the corridor along Mexico's west coast that is often traversed by commercial and pleasure watercraft, it is also not surprising that the NHC received 40 ship reports of tropical storm or hurricane conditions this year, all from east of 120°W longitude.

More than half of the tropical storm force wind reports this year came in association with Darby, which entered the eastern Pacific on the 29th of June. By the 2nd of July, a tropical depression formed some 200 nautical miles south of the Gulf of Tehuantepec. The ***Zim Japan*** filed the year's first report of tropical storm force winds late on the 3rd. This and satellite imagery indicate that the depression had strengthened into Tropical Storm Darby.

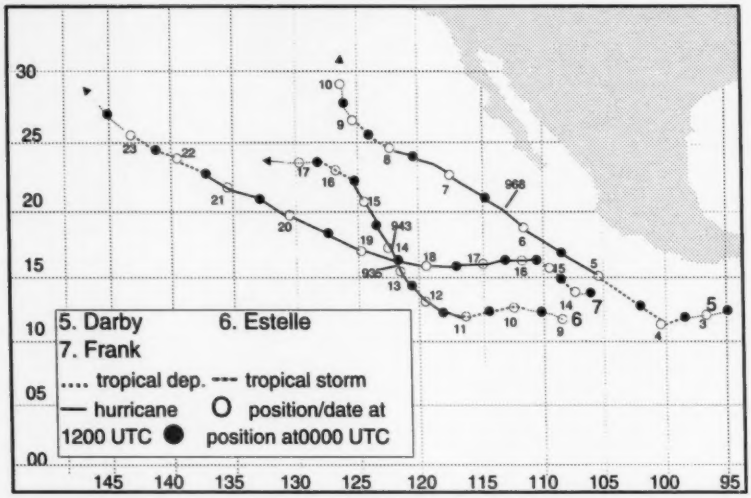
After forming, Darby began to accelerate toward the west northwest to northwest. The heading would remain nearly invariant as Darby intensified and grew. Its outer rainbands battered the southwest coast of Mexico from Acapulco to Puerto Vallarta. Some 5.75 inches of rain was dumped on Acapulco on the 3rd. According to the newspaper *Excelsior*, flooding associated with Darby killed three people and damaged about 180 small shops in Acapulco. Four fisherman were reported missing off Acapulco.

Before they abandoned, ship the crew of the **Oasis** estimated sustained winds of 95 knots in Darby.

On the night of the 4th, Darby reached hurricane strength while centered a few hundred nautical miles south of Manzanillo. The ***Silvaplana*** reported 50-knot winds on the 5th.

The hurricane passed almost directly over the island of Socorro where observations included a surface pressure of 974.5 mb and estimated sustained winds of 90–100 knots with gusts to about 110 knots.

The pleasure craft ***Oasis*** and her crew were overtaken by the hurricane in the vicinity of San Benedicto Island (just north of Socorro Island). Much of their harrowing ordeal was documented on videotape by the crew (and aired on the television show *I Witness Video*). All seven persons onboard the ***Oasis*** were rescued by the the ***Chiquita Roma***. Before they aban-



doned ship, the crew of the ***Oasis*** estimated sustained winds of 95 knots in Darby.

Darby reached its estimated peak intensity of 105 knots shortly after passing Socorro Island. Because of its great intensity, rapid forward speed, and large size, Darby weakened slowly as it passed over the much colder waters just west of Baja California. In fact, Darby remained a hurricane to almost 25°N latitude, farther north than any previous July hurricane on record in the eastern Pacific.

Darby's remnants ultimately brought rare July showers to Southern California where 7–foot waves pounded the beaches.

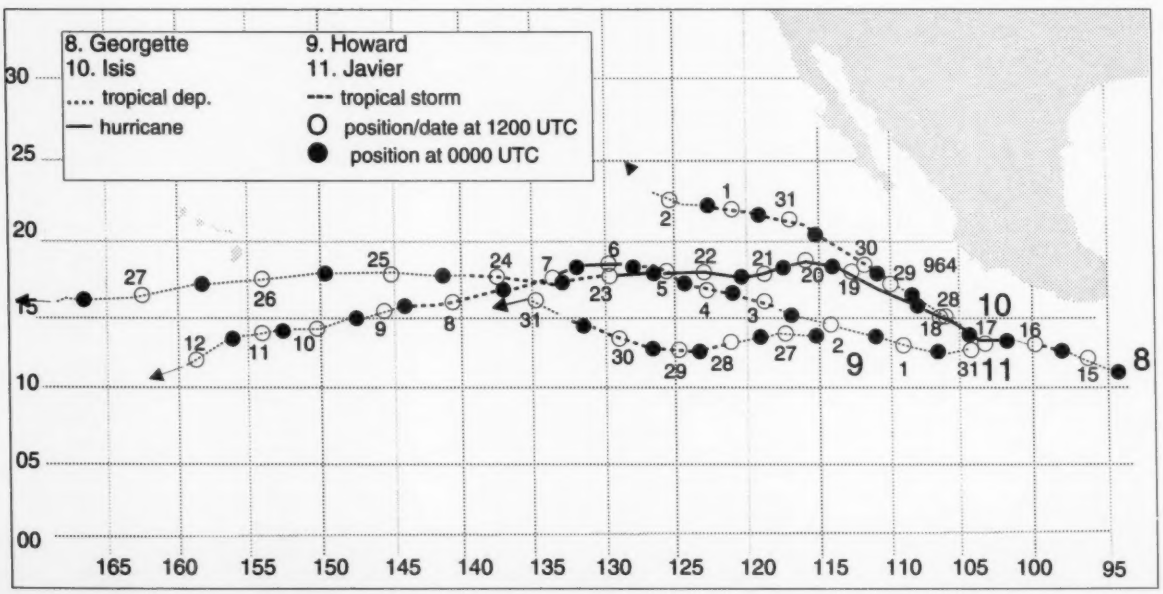
Hurricane Frank was first recognized on July 9 as an area of disturbed weather located a few hundred nautical miles south southeast of Acapulco. This area moved westward for several days and, on the 13th, became a tropical depression about 575 nautical miles south southeast of the southern tip of Baja California.

Observations from the ***Nikolai Nekrassov*** and the ***B. Prus*** helped establish that the depression had strengthened into a tropical storm on the 14th. The storm was moving northwestward then, but turned toward the west on the 15th in response to a well established deep ridge to its north. Frank became a hurricane on that date and continued to intensify, with peak winds reachingan estimated 125 knots on the 18th.

By late on the 18th, the hurricane began to turn toward the northwest and weaken over colder waters. Frank dropped to a tropical storm on the 21st and to a depression on the 23rd.

A banding–type eye formed in Lester and passed very close to the 17,000–ton, 546–foot long *Gladiator* during the evening of the 22nd.

The convection associated with a tropical wave increased upon entering the eastern Pacific on the 16th of August. By the 19th, this weather system was becoming bet-

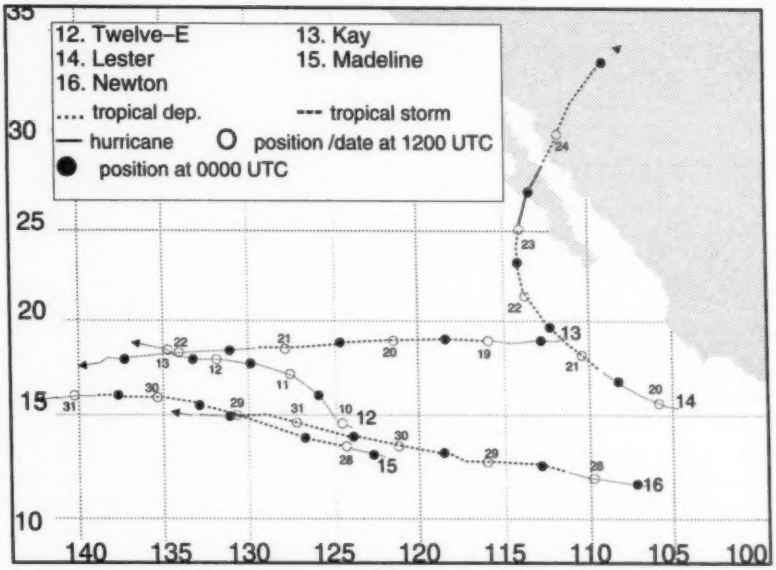


ter organized. Tropical Depression Fourteen-E centered 240 nautical miles south-southwest of Manzanillo, Mexico, developed on the night of the 19th-20th.

The depression quickly strengthened to become Tropical Storm Lester, and its center passed directly over Socorro Island near 0400 UTC on the 21st. There were no observations from the island at that time but 4 hours earlier sustained surface winds of 020° at 32 knots were reported.

Lester continued northwestward and slowly strengthened. On the 21st, the ***Century Highway No. 5*** reported 42 knot winds 150 nautical miles northeast of the center, and the ***Cape May*** reported 37-knot winds about 200 nautical miles east northeast of the center. On the basis of those ship reports, the radius of tropical storm force winds was extended in the northeast quadrant.

By early on the 22nd of August, Lester began moving toward the north and later that day reached hurricane strength, about 210 nautical miles west of La Paz, Baja California. A banding-type eye formed and passed very close to the 17,000-ton, 546-foot long ***Gladiator*** during the evening of the 22nd. That ship observed winds of at least 34 knots for 24 consecutive hours and hurricane force winds for about half a day. Their highest winds were 75 knots and their lowest pressure was 982 millibars. Hurricane conditions caused a 33-degree roll, sending a considerable amount of cargo overboard.

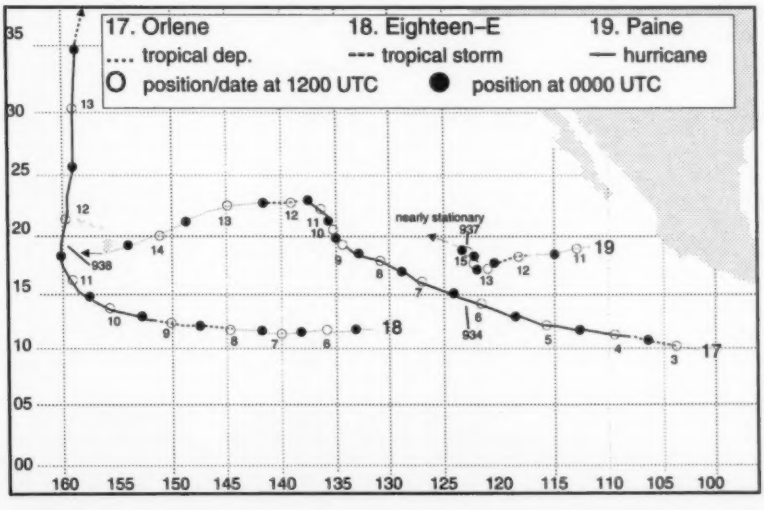


A trough along the west coast of the United States became quasi-stationary and, as a result, Lester gradually turned toward the northeast making landfall first near Punta Abreojos, Baja California on the morning of the 23rd, and then near Isla Tiburon, Mexico as a tropical storm that afternoon. Lester probably was a minimal tropical storm as far inland as Tucson, Arizona but dissipated rapidly in central New Mexico.

Rainfall totals up to 8.66 inches were reported in Baja California and Sonora, Mexico. Reportedly, the associated flooding left more than 5,000 people homeless in Mexico, and several small communities were destroyed west and northwest of Hermosillo. Lester also caused minor flooding in California, Colorado, and Utah. A storm surge of uncertain dimensions reportedly occurred near the city of Empalme when Lester moved into mainland Mexico from the Gulf of California.

The convection accompanying a tropical wave became pronounced south of the Gulf of Tehuantepec on the 13th and 14th of September. It was not until the morning of the 17th, however, that the system became a tropical depression. The following night it became Tropical Storm Seymour a few hundred miles south of the southern tip of Baja California.

Seymour reached hurricane status on the 19th of September.



As the trough was replaced by the ridge, the cyclone turned westerly and regained hurricane strength.

Over the following 24 hours, five observations of tropical storm conditions were reported from vessels located just west of the Baja. All but one came from the ***London Spirit***. The other was from the ***Alligator Liberty***.

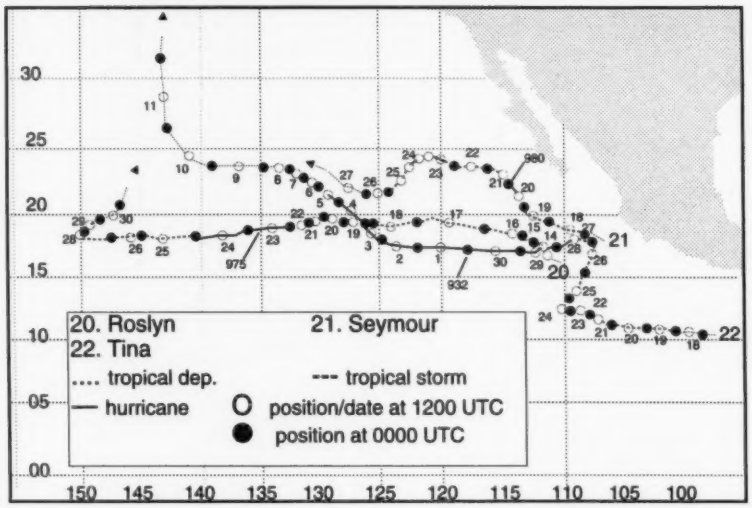
The effects of an upper-level trough, and perhaps cool ocean waters, weakened the hurricane temporarily to tropical storm strength. As the trough was replaced by a ridge, the cyclone turned westerly and regained hurricane strength.

Seymour's resurgence was short-lived, however. It soon lost all its deep convection and weakened to a tropical depression and then dissipated on the 27th of September.

Satellite images indicate that late on the 16th of September the amount of deep convection associated with a tropical wave increased and became concentrated over a small area centered about 350 nautical miles to the south of Acapulco. It is estimated that the system became a tropical depression on the morning of the 17th.

The tropical cyclone moved slowly (about 5 knots) westward through the 21st, well to the south of a deep High. Tina gradually intensified into a hurricane of 75-knot winds containing an intermittently detectable eye. The strengthening occurred despite the presence of northerly to northeasterly vertical wind shear associated with the upper-level outflow from Hurricane Seymour centered several hundred miles to the northwest.

Data from the first of several research flights by a NOAA aircraft indicate that Tina weakened back to tropical storm strength,



ending the first of its three cycles of intensification. The second cycle was underway on the 24th when Tina made a rather abrupt turn toward the west coast of Mexico. This coincided with a weakening of the ridge to the north and with a mid- to upper-level trough north of Tina.

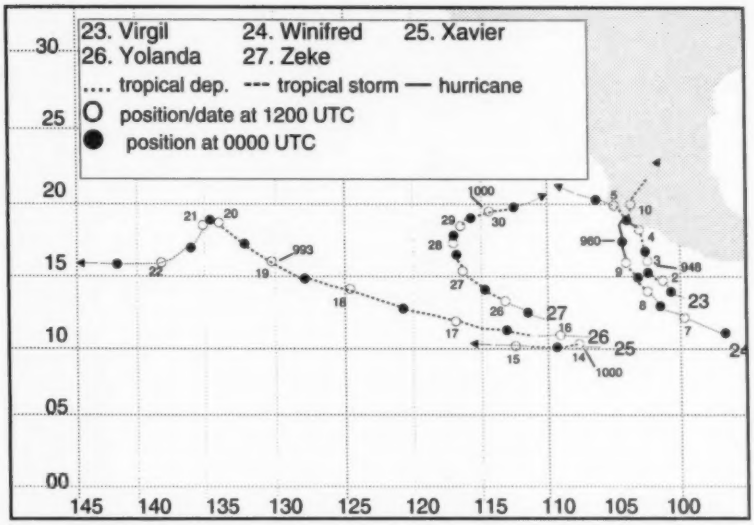
... investigations of Tina included a 944-mb central pressure and a wind speed of 125 knots at a flight level of 700 millibars ...

The trough was followed by a second and stronger High which developed west of Baja California and a ridge built southwestward. The associated steering flow turned Tina away from the coast on the 27th. Tina then strengthened for the third time and an eye of 20 nautical miles in diameter appeared. Late on the 29th, reports from a NOAA research aircraft included a 944-millibar central pressure and a wind speed of 125 knots at a flight level of 700 mb, while locating the hurricane center about 90 nautical miles to the south of Clarion Island.

Intensity estimates based on satellite data suggest that Tina was the eastern Pacific's strongest hurricane of 1992. An estimated peak of 130 knots occurred on the last day of September and early on the 1st of October.

Tina had several course adjustments during the first week of October. Eventually, it moved into an environment of progressively cooler water and moderate southwesterly wind shear. A protracted weakening trend ensued. The eye became exceptionally large, perhaps exceeding 60 nautical miles in diameter on the 4th. It became a tropical depression consisting mainly of a swirl of low clouds with a few deeper convective cells on the 7th. However, Tina then regenerated a small area of deep convection near its circulation center that persisted until the 11th of October.

Virgil formed on the 1st of October in an environment of weak vertical wind shear and warm sea surface temperatures. By mid day it became Tropical Storm Virgil centered about 400 nautical miles southeast of Manzanillo. On the 2nd and 3rd, the cyclone intensified markedly. Three ship reports of tropical storm force winds were registered during that period. One unidentified ship reported wind speeds of



58 knots and provided an estimate (presumably from radar) of Virgil's position and movement.

A distinct eye appeared on infrared satellite images at 1300 UTC on the 2nd. This observation implies that Virgil had become a hurricane while centered about 250 nautical miles to the south southeast of Manzanillo.

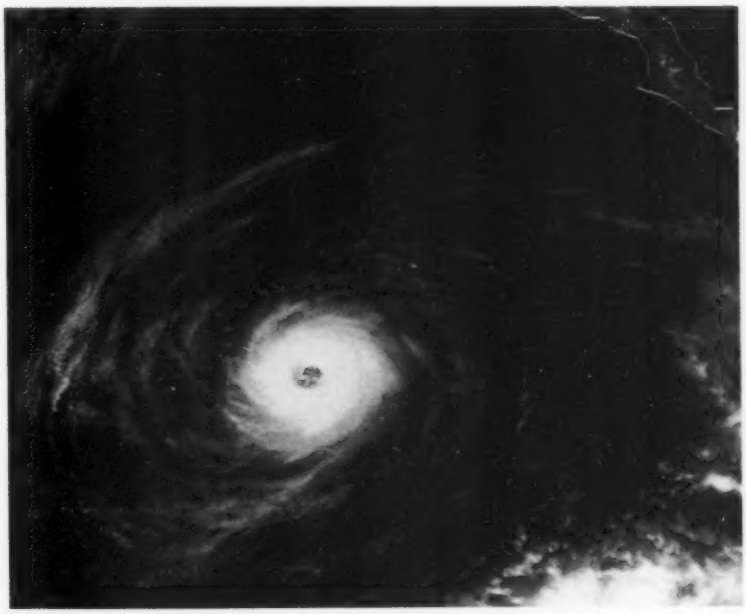
... Virgil had become a hurricane while centered about 250 nautical miles south southeast of Manzanillo.

The cyclone's forward motion shifted from northwest to north within a steering flow affected by a mid- to upper-tropospheric trough centered a few hundred miles to the northwest of Virgil. Virgil's center came within about 50 nautical miles of the coast, near Lazaro Cardenas, during the day on the 3rd, but then turned toward the north northwest and made landfall midway between Lazaro Cardenas and Manzanillo about 12 hours later.

Fortunately, Virgil had passed its peak intensity of 115 knots before making landfall. The eye was not generally discernable on satellite images when the hurricane came ashore and maximum sustained wind were estimated then to be near 95 knots. Rainfall totals up to 10 inches were reported in the state of Michoacan.

One person was reported missing in the state of Colima and three people were injured in the state of Guerrero. More than 1000 homes were damaged in Colima, Guerrero, and Michigan. In Guerrero, the Atoyac River overflowed, flooding 500 homes and prompting the evacuation of 2500 people.

Weakening accelerated after landfall, over nearby mountains. The cyclone center passed just north of Manzanillo on the 4th, but by that time Virgil was a tropical depression. Virgil reentered the Pacific near Cabo Corrientes. By the following day, only a small, weak low-level circulation remained. Strong upper-level westerlies over the area helped prevent Virgil from regenerating.



Hurricane Tina was near its estimated peak intensity of 130 knots at the time of this picture, 2101 UTC on the 30th of September 1992.

1992 Eastern North Pacific Tropical Cyclones

No.	Name	Class[a]	Dates[b]	Maximum Sustained wind (knots)[c]	Lowest pressure (mb)
1	Agatha	T	6/1–6/5	60	990
2	Two–E	D	6/16–6/18	30	1009
3	Blas	T	6/22–6/24	35	1004
4	Celia	H	6/22–7/4	125	935
5	Darby	H	7/2–7/10	105	968
6	Estelle	H	7/9–7/17	120	943
7	Frank	H	7/13–7/23	125	935
8	Georgette	H	7/14–7/27	95	964
9	Howard	T	7/26–7/30	55	992
10	Isis	T	7/28–8/2	55	992
11	Javier	H	7/30–8/12	70	985
12	Twelve–E	D	8/10–8/12	30	1006
13	Kay	T	8/18–8/22	45	1002
14	Lester	H	8/20–8/24	75	977
15	Madeline	T	8/27–8/31	45	999
16	Newton	T	8/28–9/1	45	999
17	Orlene	H	9/2–9/14	125	934
18	Eighteen–E	D	9/5–(became Iniki on 9/8)		
19	Paine	H	9/11–9/16	65	987
20	Roslyn	H	9/13–9/30	85	980
22	Tina	H	9/17–10/11	130	932
23	Virgil	H	10/1–10/5	115	948
24	Winifred	H	10/6–10/9	100	960
25	Xavier	T	10/13–10/15	40	1003
26	Yolanda	T	10/15–10/22	55	993
27	Zeke	T	10/24–10/30	45	1000

[a]D:tropical depression, wind speed less than 34 knots.
T:tropical storm, wind speed 34–63 knots.
H:hurricane, wind speed 64 knots or higher.

[b]Dates begin at 0000 Universal Time.

[c]Wind speed over a one–minute spa

Tropical Cyclone Winds

(ship encounters of 34 knots or higher)

Tropical Cyclone	Ship Name	Date Mo/Da	Time UTC	Position LatN	LonW	Wind(kn) Dir/Speed	Pressure (mb)
Darby	*Zim Japan*	7/03	2100	14.0	95.2	130/35	1006.0
	Silvaplana	7/04	1500	17.1	102.9	090/34	1009.0
	Lincolnshire	7/05	0000	18.0	103.4	130/40	1007.3
	Eva	7/05	0200	19.0	105.0	090/45	–
	Silvaplana	7/05	0300	18.4	105.5	120/43	1005.5
	Lincolnshire	7/05	0300	18.0	103.3	120/35	1009.6
	Silvaplana	7/05	0600	18.8	106.0	110/40	1007.0
	Silvaplana	7/05	1200	19.9	107.1	110/50	1007.0
	Century Leader No. 5	7/05	1500	19.0	105.4	130/38	1008.0
	Silvaplana	7/05	1500	20.4	107.6	110/48	1009.0
	CPC Holandia	7/05	1500 1	5.0	108.2	250/44	997.5
	Silvaplana	7/05	1800	20.9	108.1	090/34	1009.0
	Silvaplana	7/05	2100	21.4	108.7	090/34	1008.2
	Oasis	7/05		19.4	110.9	---/95	
	Pacific Sandpiper	7/06	0000	20.3	107.9	130/37	1005.5
	Silvaplana	7/06	0000	21.8	109.3	090/34	1006.0
	Silvaplana	7/06	0300	22.2	109.9	090/34	1008.0
	Oaxaca	7/06	0300	22.7	110.9	120/35	1007.0
	Oaxaca	7/06	0600	22.6	110.4	110/34	1008.5
	Silvaplana	7/06	1500	23.6	112.4	090/34	1011.0
	ELEM2	7/06	1800	24.4	112.9	130/47	1012.8
Frank	*Nikolai Nekrassov*	7/14	1800	13.4	104.3	190/35	1009.8
	Pisces Planter	7/15	1200	16.1	107.3	210/37	1008.0
	USNS Victorious	7/19	0000	13.4	119.9	190/35	1008.0
Lester	*Century Highway No. 5*	8/21	1800	21.3	109.4	100/42	1008.1
	Cape May	8/21	1800	21.9	110.8	30/37	1011.1
	Gladiator	8/22	1700 through 1600 8/23 near 25°N 113°W: wind 34 to 75 knots, pressure 982 to 1005 mb				
Paine	*Venus Diamond*	9/16	1200	15.5	119.9	210/44----------	
Seymour	*London Spirit*	9/20	1200	24.2	113.2	100/35	1002.9
	London Spirit	9/20	1500	24.2	113.9	130/35	1003.8
	London Spirit	9/20	1800	24.0	112.7	130/40	1004.4
	London Spirit	9/21	0000	23.2	112.1	150/45	1003.5
	Alligator Liberty	9/21	0000	23.6	112.4	160/35	1003.2
Tina	*South Land Star*	9/25	1200	13.7	107.5	210/40	1006.2
	World Wing II	9/27	0000	16.2	107.5	210/34	1005.5
	(unknown)	9/27	1200	15.2	106.7	180/35	1002.0
Virgil	*Huta Lenina*	10/02	2100	15.5	102.3	180/40	1000.0
	(unknown)	10/03	0000	15.3	102.2	230/58	1002.1
	(unknown)	10/03	0300	15.0	102.2	250/46	1004.8
	Sky Princess	10/03	1200	16.9	100.9	080/37	1005.1
Winifred	*B. T. Alaska*	10/09	0000	16.9	100.8	090/36	1007.0

North Atlantic Hurricanes – 1992

Max Mayfield and Lixion Avila
National Hurricane Center

Only one hurricane made landfall in the contiguous United States in 1992– Andrew. A small and ferocious Cape Verde hurricane, Andrew wrought unprecedented economic devastation along a path through the northwestern Bahamas, the southern Florida peninsula, and south-central Louisiana. Damage in the United States is estimated at $20–25 billion, making Andrew the most expensive natural disaster in U.S. history. The tropical cyclone struck southern Dade County, Florida especially hard, with violent winds and storm surges characteristic of a category 4 hurricane on the Saffir-Simpson Hurricane Scale (SSHS), and with a central pressure (922 millibars) that is the third lowest this century for a hurricane at landfall in the United States. In Dade County alone, the forces of Andrew resulted in 15 deaths, and as many as one-quarter million people were made homeless. The direct loss of life seems remarkably low considering the enormous destruction caused by this hurricane.

There were six tropical storms of which four became hurricanes during the 1992 hurricane season. In addition, one subtropical storm formed during the year. While subtropical storms are relatively rare events, on the average ten are named tropical storms and six become hurricanes. For the second year in a row, no system reached hurricane intensity south of 25°N.

Subtropical Storm One

Subtropical Storm One formed from a non-frontal low pressure system about 600 nautical miles southeast of Bermuda on April 21st. Satellite imagery showed a large comma-shaped cloud pattern associated with the Low. Ship reports indicated that the Low was also present at the surface, and the subtropical depression stage began at this time.

The decision to issue advisories on this system was based primarily on the report from the ***Chiquita Belgie*** at 0600 UTC on the 22nd. The ship (25.0°N 61.0°W) reported a wind speed of 45 knots and a pressure of 1004.1 millibars. Its pressure tendency indicated that the pressure had been even lower during the preceding 3 hours. This was the basis for estimating a maximum wind speed of 45 knots and a minimum surface pressure of 1002 millibars associated with the system. By late on the 23rd, the storm weakened back to a depression and nearly stalled as strong upper-level westerly winds began to affect the area. It soon deteriorated into a low-level cloud swirl which eventually dissipated.

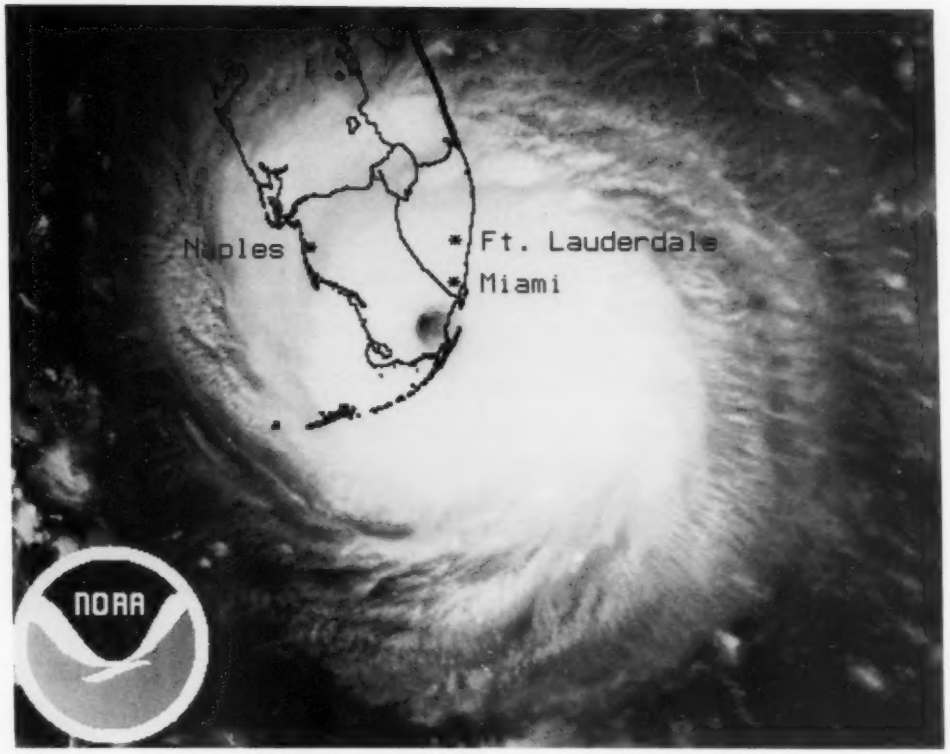
Prior to 1992, April had been the only month during which no tropical or subtropical storm had formed. However, subtropical cyclones have only been tracked since 1968 (tropical cyclone records go back to 1871), and it is possible that some systems that were designated extratropical prior to 1968 could have been subtropical.

Hurricane Andrew

Hurricane Andrew formed from a tropical wave which moved off the west coast of Africa on the 14th of August. The wave passed to the south of the Cape Verde Islands the following day and reached tropical depression stage on the 16th. By the 17th, it became Andrew, the first Atlantic tropical storm of the 1992 hurricane season. The tropical cyclone continued moving rapidly in the general direction of the Lesser Antilles.

Between the 17th and 20th, the tropical storm passed south of a High over the eastern Atlantic and changing steering currents gradually forced Andrew away from the Lesser Antilles towards a strong

Max Mayfield and Lixion Avila are Hurricane Specialists at NOAA's National Hurricane Center in Miami, FL. Also contributing to this report were Hal Gerrish, Miles Lawrence, Richard Pasch and Ed Rappaport.



Andrew's eye is over land at 0916 UTC on the 24th of August just minutes after a central pressure of 922 mb was estimated at Homestead Air Force Base. This is the view from NOAA-11 and is infrared data. During landfall the maximum sustained wind speed was estimated at 125 knots with gusts to near 150 knots at the standard elevation of 30 feet. The sustained wind speed is based on a 1 minute average.

upper-level low pressure system centered about 500 nautical miles to the east-southeast of Bermuda. Andrew was then under the influence of strong southwesterly vertical wind shear and quite high surface pressures to its north. Air Force Reserve unit reconnaissance aircraft, on the 20th, found that the cyclone had degenerated and only a diffuse low-level circulation center remained.

Significant changes in the large-scale environment near and downstream from Andrew began by the 21st. The upper low east-southeast of Bermuda weakened and split resulting in a decrease of the vertical wind shear over Andrew while a strong, deep high pressure cell formed near the U.S. southeast coast with a ridge extending eastward just north of Andrew. The cyclone turned westward, accelerated to near 16 knots, and quickly intensified.

Andrew reached hurricane strength on the morning of the 22nd as an eye formed and the rate of strengthening increased. Just 36 hours later, Andrew reached the borderline between a category 4 and 5 hurricane and was at its peak intensity.

The High held steady and drove Andrew nearly due west for 2½ days beginning on the 22nd. Andrew was a category 4 hurricane when its eye passed through the Bahamas– over northern Eleuthera Island late on the 23rd and over the southern Berry Islands early on the 24th.

Andrew weakened when it passed over the western portion of the Great Bahama Bank and the pressure rose to 941 millibars. However, it rapidly reintensified during the last few hours preceding landfall on Florida as it moved over the Straits of Florida. It is estimated that the central pressure was 922 millibars at landfall near Homestead AFB, Florida at 0905 UTC (5:05 A.M. EDT) on the 24th of August.

The maximum sustained surface wind speed (1-minute average at 30 feet elevation) during landfall over Florida is estimated at 125 knots, with gusts at that elevation near 150 knots. The sustained wind speed corresponds to a category 4 hurricane on the Saffir-Simpson scale. Locally stronger winds occurred at heights more than 30 feet above the ground, such as on taller structures. Several unofficial reports of stronger gusts are being evaluated.

Andrew moved nearly due west and crossed the extreme southern portion of the Florida peninsula in about 4 hours. Although it weakened about one category on the Saffir-Simpson scale during this transit, and the pressure rose to about 950 millibars, Andrew was still a major hurricane when its eyewall passed over the extreme southwestern

1992 Atlantic Hurricane Season Statistics

no.	name	class[a]	dates[b]	maximum sustained wind(knots)[c]	lowest pressure (mb)	U.S. damage ($billions)	direct deaths[d]
1	One	ST	Apr. 21–24	45	1002		
2	Andrew	H	Aug. 16–28	135	922	20–25	26
3	Bonnie	H	Sep. 17–30	95	965		1
4	Charley	H	Sep. 21–27	95	965		
5	Danielle	T	Sep. 22–26	55	1001		2
6	Earl	T	Oct. 26 Sep–3	55	990		
7	Frances	H	Oct. 23–27	75	976		

[a] ST: subtropical storm, wind speed 34–63 kn.
T: tropical storm, wind speed 34–63 kn.
H: hurricane, wind speed 64 kn or higher.

[b] Dates begin at 0000 UTC and include tropical depression stage.

[c] Wind speed over a one–minute span.

[d] Includes deaths outside the United States.

Florida coast.

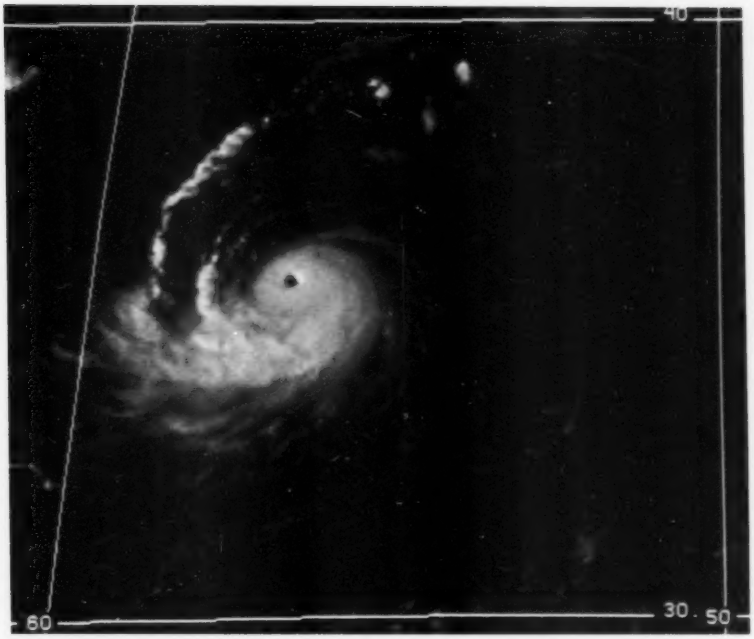
The first of two cycles of modest intensification began when the eye reached the Gulf of Mexico. Also, the hurricane continued to move at a relatively fast pace while its track gradually turned toward the west–northwest.

As Andrew reached the north–central Gulf of Mexico, the High to its northeast weakened and a strong mid–latitude trough approached from the northwest. Andrew turned toward the northwest and its forward speed decreased to about 8 knots. The hurricane struck a sparsely populated section of the south–central Louisiana coast with category 3 intensity at about 0830 UTC on the 26th. The landfall location was about 20 nautical miles west–southwest of Morgan City.

Andrew weakened rapidly after landfall, to tropical storm strength in about 10 hours and to depression status 12 hours later. Andrew and its remnants continued to produce heavy rain that locally exceeded 10 inches near its track. By midday on the 28th, Andrew had begun to merge with a frontal system over the mid–Atlantic states.

Andrew came ashore in the northwest Bahamas and southeast Florida near high tide and was accompanied by a locally huge storm surge. The surge at Current Island, near the northern end of Eleuthera Island, reached a phenomenal 23 feet. The 16.9–foot storm tide (the sum of storm surge and astronomical tide) which headed inland from Biscayne Bay is a record maximum for the southeast Florida peninsula. Storm tides in Louisiana were at least 7 feet and caused flooding from Lake Borgne westward through Vermillion Bay. The maximum storm tide on the Florida southwest coast is estimated at 5 to 7 feet.

There have been no confirmed reports of tornadoes associated with Andrew over the Bahamas or Florida. Funnel sightings, some unconfirmed, were reported in the Florida counties of Glades, Collier and Highlands, where Andrew crossed in daylight. In Louisiana, one tornado occurred in the city of Laplace several hours prior to Andrew's landfall. That tornado killed 2 people and injured 32 others. Tornadoes in the Ascension, Iberville, Baton Rouge, Pointe Coupee, and Avoyelles parishes of Louisiana reportedly did not result in casualties. Numerous reports of funnel clouds were received by officials in Mississippi, and tornadoes were suspected to have caused damage in several Mississippi counties. In Alabama, the occurrence of two damaging tornadoes has been confirmed over the mainland while



This METEOSAT visible satellite image of Hurricane Bonnie was taken at 1930 UTC on the 19th of September. At this time Bonnie had begun to move toward the east northeast and was exhibiting a fairly well-defined eye. The eye became indistinct at times on the 20th, but on the 21st, satellite images showed that it again had become sharp and it was at this time that the storm reached peak intensity.

another tornado may have hit Dauphin Island. As Andrew and its remnants moved northeastward over the eastern states, it continued to produce severe weather. For example, several damaging tornadoes in Georgia late on the 27th of August were attributed to Andrew.

A preliminary report on Hurricane Andrew was published in the fall 1992 *Mariners Weather Log*.

Hurricane Bonnie

Bonnie formed a few hundred nautical miles east of Bermuda on the western end of a frontal trough. The tropical depression stage began on September 17th when satellite imagery showed a cloud pattern had organized into cyclonically curved bands and a small circularly-shaped overcast feature. The depression strengthened fairly rapidly, and became Tropical Storm Bonnie on the 18th. Bonnie moved slowly along a counterclockwise path before strengthening into a hurricane late on September 18th.

Bonnie reached its peak intensity with estimated maximum winds of 95 knots and minimum pressure of 965 millibars on the 21st. Bonnie was practically stationary from late on the 22nd until midday on the 23rd, when it began drifting west-southwestward. Winds decreased to tropical storm strength on the 24th. On the 26th Bonnie weakened briefly to a tropical depression, but regained tropical storm strength later in the day.

It moved through the Azores before losing tropical characteristics. Lajes Air Force Base in the Azores reported sustained winds of 35 knots with gusts to 51 knots as Bonnie passed nearby. Wind gusts to 59 knots were reported atop a 240-foot tower at Lajes.

One death attributed to Bonnie, was the result of a rockfall on the island of St. Michaels in the Azores.

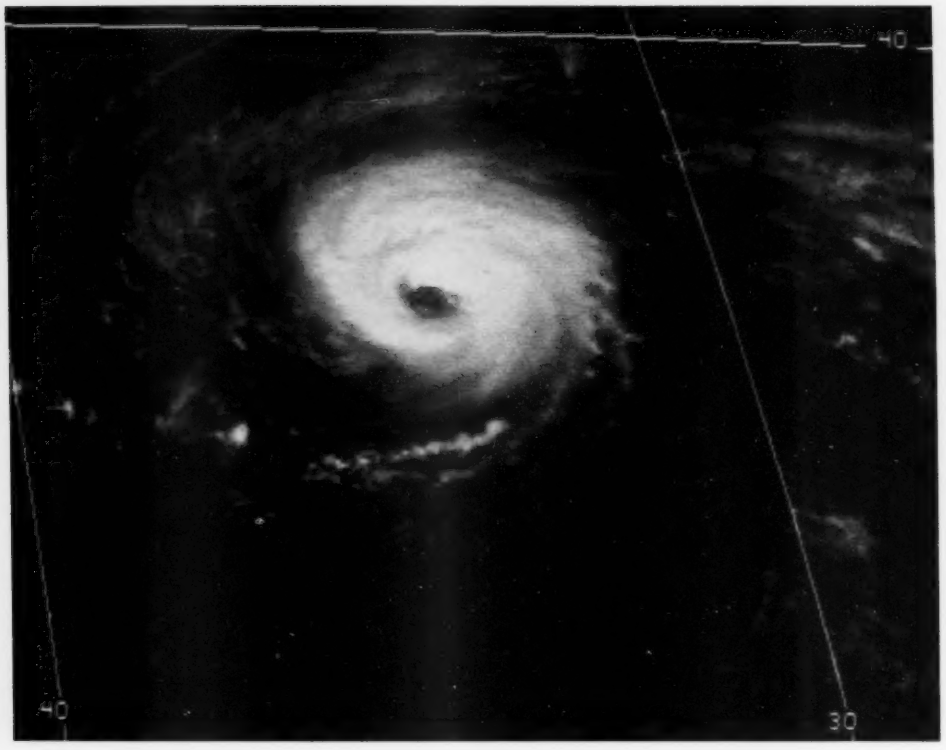
A number of ships reported winds of tropical storm force associated with Bonnie. One ship, the ***Al Naseer***, reported tropical storm force winds on 4 consecutive days while paralleling the track of Bonnie.

Andrew and NHC

Although the National Hurricane Center (NHC) and Miami Weather Service Forecast Office (WSFO) were not in the eyewall of Andrew, they still encountered considerable effects of the hurricane. The radome was blown off the top of the 12 story building housing their offices, and the two large satellite data receiving antennas at ground level were ripped to shreds. The loss of commercial power, an inoperative water system, and the loss of air-conditioning made working conditions less than desirable. However, back-up generators provided power, and the NHC continued issuing all tropical cyclone related products even after being struck by Andrew. This was in spite of the fact that many employees suffered extensive damage to their homes. At the time of this writing, several employees remain dislocated while reconstruction of their homes continues.

Hurricane Charley

Satellite imagery showed that cloudiness and showers became concentrated in an area south of the Azores early on September 20th. Animation of the satellite imagery suggested that a mid- to upper-level cyclonic circulation was interacting with the northern portion of a tropical wave. The system became a tropical depression on the 21st about 550 nautical miles southwest of the Azores. The following day it headed northward as Tropical Storm Charley, influenced in part by the flow around slow-moving Hurri-



This is a METEOSAT visible satellite image of Hurricane Charley at 1430 UTC on the 24th of September, a few hours before it attained its maximum strength. Its minimum central pressure dipped to 965 millibars while maximum sustained winds were estimated at 95 knots. The following day Charley began moving toward the east and eastnortheast with increasing forward speed and over progressively cooler water.

cane Bonnie some 1000 nautical miles to the northwest. An eye formed and Charley became a hurricane on the 23rd. It reached a peak the following day with estimated maximum sustained winds of about 95 knots and minimum central pressure of 965 millibars.

By the 25th, Charley was moving over progressively cooler water. It was downgraded to a tropical storm on September 27th just southwest of the Azores. The storm center passed over the island of Terceira. Lajes AFB reported a minimum pressure of 982.4 millibars with a sustained wind of 46 knots and gusts to 71 knots. The ***Ango*** reported winds of 38 knots and a pressure of 983 millibars near the center of Charley at 1500 UTC on the 27th. The storm gradually lost tropical cyclone characteristics as it moved over cooler water and became an extratropical cyclone late on the 27th.

Tropical Storm Danielle

Danielle originated within a persistent area of low pressure near the southeast U.S. coast. A weak tropical wave moved into this area on the 18th of September. A cold front merged with the northern portion of this stationary weather system on the 20th.

By the 22nd, surface reports and satellite imagery showed that a better defined cyclonic circulation about 175 nautical miles south southeast of Cape Hatteras, North Carolina-- most likely a tropical depression. An Air Force Reserve unit aircraft reported 45-knot flight-level winds, and the depression was upgraded to Tropical Storm Danielle that same day.

Danielle turned a small clockwise loop on the 23rd and 24th followed by a westward motion toward the Outer Banks of North Carolina on the 25th. However, the storm soon turned northward and some strengthening occurred as the storm paralleled the coast of North Carolina. Sustained winds increased to 55 knots and the central pressure fell to 1001 millibars.

The center of the storm moved inland over the Delmarva Peninsula late on the 25th. The weakening storm moved across Maryland and Delaware and over eastern Pennsylvania on the 26th, where it dissipated. There were several coastal reports of tropical storm force winds from North Carolina, Virginia and Delaware. The highest sustained wind speed reported from a land station was 44 knots at Cape Charles, Virginia. Several ship reported winds of 34 knots or higher. A report of 64 knots from the ***Stonewall Jackson*** is suspected of being somewhat too high although it was near the center of the storm at the time and its

pressure of 1001 millibars agrees with the reconnaissance value mentioned above. Also, offshore data buoys as far north as New York Harbor reported tropical storm force winds. The highest storm surge reported was 5.4 feet above normal astronomical tide at Cape Hatteras, North Carolina.

Two deaths resulted from a sailboat being battered and sunk by high seas to the east of New Jersey. There was minor flooding and significant beach erosion along the mid-Atlantic coast. According to press reports, only minor damage resulted from the storm.

Tropical Storm Earl

Earl formed from a tropical wave that exited the coast of Africa on September 18th. The wave developed into a tropical depression a few hundred nautical miles north of Hispaniola on the 26th and moved toward the west-northwest, steered by the flow induced by, in part, a middle to upper-level low over Cuba. However, a cold front sweeping across the eastern United States forced the depression to become nearly stationary over the warm waters of the Gulf Stream. There the depression strengthened. Data from an Air Force Reserve unit reconnaissance plane, buoys, and ships indicated that the depression became Tropical Storm Earl on the 29th. By then Earl was already moving eastward ahead of the cold front. The tropical storm was able to maintain its low-level circulation, staying detached from the surface frontal boundary for several days. It reached its peak intensity of 55 knots and 990 millibars on October 2nd.

Earl continued moving on a general east-southeast track, producing transient convection but maintaining a well-defined low-level circulation. Finally, the storm weakened to a tropical depression by midday on the 3rd and lost its tropical characteristics later on that day.

Hurricane Frances

Frances formed from a low pressure area on the trailing end of a frontal trough about 400 nautical miles south-southeast of Bermuda. The low strengthened and became a gale center of about 1004 millibars late on the 22nd of October. The deep convection then began to wrap cyclonically around the circulation center and grew in lateral extent. The system was making a transition from a gale center to Tropical Storm Frances. The transformation was completed early on the 23rd.

Several ship reports documented the storm intensification during the transition period. The ***Migaea*** observed a pressure of 1000 millibars about 150 nautical miles from the circulation center late on the 22nd. By early on October 23rd, the ***Migaea*** was closer to the center and observed 997 millibars with sustained winds of 50 knots and gusts to 74 knots. The ***Sparrow*** reported sustained winds of about 50 knots late on the 22nd. Before sunrise on the 23rd, sustained winds approached 65 knots on the ***Sparrow*** but then dropped temporarily to 34 knots while the wind direction switched from southeast to northwest. Those changes coincided with the sky partially clearing and the pressure reaching 996 millibars after falling rapidly for several hours. These observations suggest that the first stages in the formation of an eye occurred early on the 23rd. It is estimated that Frances reached hurricane strength on this date, a few hours prior to the initial aircraft reconnaissance mission in the cyclone which found a 979 millibars central pressure.

Frances initially drifted northward, in the general direction of Bermuda. By late on the 23rd, the associated steering flow began to accelerate Frances northeastward to about 20 knots. Frances reached its peak intensity, with estimated 75 knot sustained winds and 976 millibars central pressure, on the 24th.

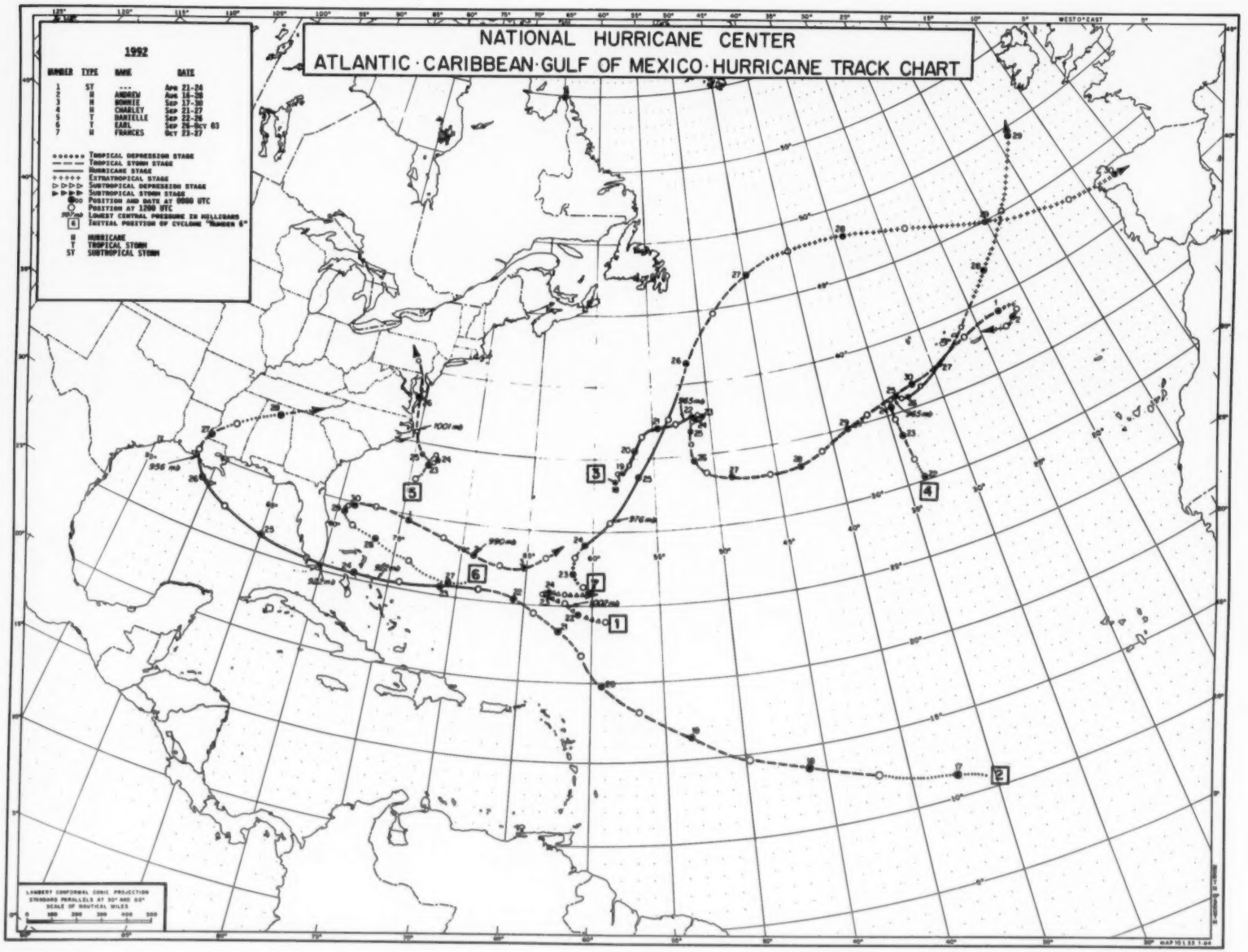
The northeastward track carried Frances over colder water. The eye became indistinct on the 25th although relatively deep convection persisted near the circulation center through early on the 27th. Analyses of surface weather maps indicate a gradual broadening of the wind field during that period, and Frances became extratropical on this day. Over the following three days, Frances moved generally to the east as a complex extratropical gale.

The only injury associated with Frances reported to the NHC occurred to Ms. Anita Page aboard the 35-foot sailboat ***Sparrow***. She suffered a broken rib, and the boat was partially disabled during her encounter with the cyclone on the 22nd and 23rd.

A post-analysis of Frances' formation using all the currently available data indicates that although satellite imagery provided qualitative clues about Frances' initial transformation, the intensity estimates using satellite data were much too low, particularly from the 22nd-24th. It is also unfortunate that the ***Migaea*** and ***Sparrow*** ship reports were not available operationally to the NHC. Such data deficiencies are not uncommon and in this case contributed to underestimates of the intensity of the cyclone in the NHC High Seas Forecasts and Tropical Cyclone Advisories during that period. The dearth of quantitative surface data will likely continue to limit the NHC's ability to assess accurately the intensity of cyclones that undergo rapid strengthening and/or structural change.

Tropical Cyclone Winds
(ship encounters of 34 knots or higher)

Tropical Cyclone	Ship Name	Date Mo/Da	Time UTC	Position LatN	Position LonW	Wind (kn) Dir/Speed	Pressure (mb)
ST One	Chiquita Belgie	4/22	0600	25.0	61.0	180/45	1004.1
Andrew	ELLE2	8/19	1500	19.4	56.6	--/35	1013.5
	TSS Carnivale	8/24	0600	28.1	79.2	--/35	1015.5
	Mercandian Continent	8/25	1200	29.5	80.6	--/60	----
Bonnie	LGG6	9/18	1200	31.0	55.3	200/35	1017.0
	Trenntsee	9/27	1200	30.7	42.1	230/42	1006.0
	Al Naseer	9/27	1500	29.6	44.0	240/36	1006.3
	Al Naseer	9/28	0600	30.2	40.6	230/35	1007.5
	Al Naseer	9/28	1200	30.9	39.5	240/38	1010.1
	Geesthaven	9/28	1200	35.8	40.9	040/45	1007.4
	Nord-Energy	9/28	1200	34.5	39.5	120/34	1003.0
	Geesthaven	9/28	1500	35.2	41.5	020/45	1007.7
	Nord-Energy	9/28	1800	34.5	41.0	020/60	1002.0
	Moraybank	9/28	2100	35.2	40.4	020/40	999.7
	Al Naseer	9/29	0300	32.7	36.6	240/37	1009.3
	Al Naseer	9/29	1200	33.9	34.8	220/40	1006.5
	Al Naseer	9/29	1500	34.1	34.2	210/48	1004.5
	Al Naseer	9/30	0600	34.9	30.5	250/44	1009.9
	Atlantis II	9/30	0600	38.8	30.1	030/58	1000.1
	Zim Korea	9/30	1200	35.8	26.9	260/47	1010.0
Charley	CGM Provence	9/23	1500	35.3	35.9	350/37	1011.5
	Chiquita Deutschland	9/23	1800	34.3	33.1	190/41	1015.1
	Trenntsee	9/25	1200	34.9	32.6	200/37	1005.0
	Trenntsee	9/25	1800	34.2	33.2	270/38	1007.4
	Ango	9/27	1500	39.7	25.7	010/38	983.0
Danielle	Unknown	9/24	0300	35.6	75.3	040/37	1009.7
	Jo Elm	9/24	0600	33.6	77.0	360/35	1016.5
	Export Patriot	9/24	2100	35.5	75.4	020/35	1015.0
	Gypsum King	9/25	0000	36.4	75.6	040/38	1019.0
	Unknown	9/25	0300	36.9	75.9	040/35	1021.9
	San Martin	9/25	1500	36.7	73.9	150/36	1017.0
	Stonewall Jackson	9/25	1500	36.6	75.3	010/64	1001.0
Earl	Unknown	9/28	1300	28.6	78.8	140/40	1004.0
	Deppe America	9/29	0900	29.0	78.6	160/54	1007.0
	DSR Europe	9/30	0300	30.5	79.9	010/38	1008.0
	Unknown	9/30	0600	30.8	79.6	020/38	1008.7
	Nuevo San Juan	9/30	1200	29.3	79.9	050/37	1011.0
	Unknown	9/30	1500	30.5	77.5	020/36	1005.5
	D5HD	10/01	0000	27.8	74.3	230/36	1007.3
	CGDJ	10/01	1200	27.5	72.7	300/34	1008.0
Frances	Horncliff	10/22	1200	27.2	63.3	060/44	1012.5
	Migaea	10/22	2230	26.3	64.3	110/25	1000.0
	Sparrow	10/22	2300	27.7	60.7	--/50	----
	Migaea	10/23	0200	27.7	61.5	225/50	997.0
	Solaris	10/23	0600	27.1	54.5	130/40	1010.8
	Sparrow	19/23	0900	27.7	60.7	--/64	996.0
	Sparrow	10/23	1500	27.7	60.7	--/45	----
	TSL Bold	10/23	1600	28.0	61.1	225/55	994.0
	Unknown	10/23	1945	27.8	62.3	290/44	1002.0
	TSL Bold	10/23	2000	28.0	60.8	225/65	994.0
	Barentzgracht	10/24	0000	31.0	63.5	010/37	1008.7
	Reed Voyageur	10/24	0300	28.5	65.3	315/35	----
	TSL Bold	10/24	0400	27.5	61.5	290/40-45	1005.0
	Westward	10/24	0800	32.1	58.9	060/35	1002.0
	Westward	10/24	1100	32.1	59.5	060/35	999.5
	Westward	10/24	1500	31.0	60.0	310/55	1002.7
	Pacific Teal	10/24	1500	27.8	56.3	220/40	1009.0
	Ultramar	10/24	1800	27.5	59.5	320/50	1010.2
	Yucatan	10/24	1800	29.7	55.5	220/42	1005.0
	Northern Enterprise	10/24	1800	33.4	56.4	130/40	997.1
	Yucatan	10/25	0000	29.3	56.3	240/40	1009.8
	Northern Enterprise	10/25	0000	32.9	57.9	330/42	998.2
	Professor Szafer	10/25	1200	31.9	54.7	250/50	1012.2
	Sheldon Lykes	10/25	1200	35.7	50.2	210/35	1008.9
	Star Florida	10/25	1200	40.4	56.3	030/38	1006.0
	Paleisgracht	10/25	1200	40.2	55.5	040/34	1003.1
	Tampa Bay	10/25	1500	39.1	56.9	020/50	1002.0
	Paleisgracht	10/25	1800	39.3	55.5	330/38	997.8
	Global Link	10/25	1800	41.3	55.6	020/40	998.0
	Baron	10/25	2100	42.0	53.8	360/45	993.0
	Star Florida	10/26	0000	39.4	54.8	280/38	1004.0
	Baron	10/26	0000	41.6	53.8	350/45	992.5
	Wilfred Templeman	10/26	0000	43.6	51.6	070/45	998.1
	Baron	10/26	0300	41.2	53.6	300/45	997.0
	Wilfred Templeman	10/26	0600	43.5	51.5	030/35	988.1
	Baron	10/26	0600	40.8	53.4	270/44	1002.0
	Baron	10/26	0900	40.6	52.5	270/38	1006.0
	Scandutch Gallia	10/26	1200	40.0	47.7	240/35	1010.0
	Ever Globe	10/26	1200	40.6	44.3	200/40	----
	Sealand Commitment	10/26	1200	43.7	44.7	200/35	1004.0
	Wilfred Templeman	10/26	1200	43.9	51.2	320/35	997.6
	Poliarnii Kroug	10/26	1200	47.8	47.5	090/37	1012.2
	Sealand Commitment	10/26	1500	43.6	45.6	210/48	----
	Sheldon Lykes	10/26	1800	35.8	58.2	260/35	1007.1


NATIONAL HURRICANE CENTER
ATLANTIC · CARIBBEAN · GULF OF MEXICO · HURRICANE TRACK CHART
1992
NUMBER TYPE NAME DATE
1 SY --- Aug 21-24
2 H ANDREW Aug 16-28
3 H BONNIE Aug 17-30
4 H CHARLEY Aug 21-27
5 T DANIELLE Sep 22-26
6 T EARL Sep 26-Oct 03
7 H FRANCES Sep 23-27
TROPICAL DEPRESSION STAGE
TROPICAL STORM STAGE
HURRICANE STAGE
EXTRATROPICAL STAGE
SUBTROPICAL DEPRESSION STAGE
SUBTROPICAL STORM STAGE
POSITION AND DATE AT 0000 UTC
POSITION AT 1200 UTC
LOWEST CENTRAL PRESSURE IN MILLIBARS
INITIAL POSITION OF CYCLONE "Number 6"
H HURRICANE
T TROPICAL STORM
SY SUBTROPICAL STORM
LAMBERT CONFORMAL CONIC PROJECTION
STANDARD PARALLELS AT 20° AND 50°
SCALE OF NAUTICAL MILES
0 100 200 300 400 500
WEST 0° EAST

Central North Pacific Hurricanes — 1992

Andrew K. T. Chun
Central Pacific Hurricane Center

The 1992 season in the Central Pacific will be long remembered as the year of Iniki (the Hawaiian name for Enid).

Iniki was the costliest and most powerful hurricane to strike the Hawaiian Islands. The hurricane did more than $1 billon dollars worth of damage as its eye passed directly over the island of Kauai. It was the sixth costliest storm in the history of the United States.

The Central Pacific Hurricane Center had one of its most active seasons in 1992, handling a total of 11 tropical cyclones. Three of the systems became full blown hurricanes in or prior to entering the central Pacific Ocean. Three tropical cyclones formed in the central Pacific region (between 140°W and the International Dateline) and the others were escapees from eastern waters. Iniki entered the central Pacific as an unamed tropical depression.

The season started on January 28 with Tropical Depression One-C which was subsequently upgraded to a tropical storm named Ekeka and later to a hurricane. Ekeka was followed by Hali which had its beginnings as Tropical Depression Two-C on March 28. The season then remained uneventful until early

Paradise temporarily lost– Wailua Falls (left) on Kuai at a more peaceful time (B.I.) Before Iniki. This photograph was kindly loaned to us by the Hawaii Visitors Bureau and was taken by Peter French. Hurricane Iniki wrought destruction totaling $1.8 billion on this island alone. Ironically, it came during the filming of Jurrasic Park, whose plot involves the impending disaster from an approaching tropical cyclone. The prehistoric setting must have looked even more realistic when Iniki arrived although everyone on Kuai was battened down for what proved to be Hawaii's worst tropical cyclone disaster.

September when Hurricane Iniki started as Tropical Depression Thirteen–E in the eastern Pacific.

Tropical Depression Three–C capped the season off November 21–22, forming south of the Big Island of Hawaii and never intensifying past the depression stage. This summary concentrates on Iniki and the two central Pacific tropical cyclones that reached tropical storm intensity.

Hurricane Iniki
September 5–13, 1992

Hurricane Iniki formed over the warm Pacific waters near 12°N,135°W on September 5 about 1,450 nautical miles southwest of Baja, California. This is somewhat farther west and south than the initial location of most mid season storms. The system developed from an area of disturbed weather which had been tracked for several days, by the National Hurricane Center, across Central America and into the Pacific on August 28. It may have originated as a tropical wave off the coast of Africa earlier in the month. Labeled Tropical Depression Eighteen–E, it moved westward, crossing 140°W into the Central Pacific on the morning of September 6. The system was expected to dissipate, however, by 2100 UTC on the 7th, it was still a tropical depression near 11°N,143°W, and was embedded in a fairly deep easterly flow along the south edge of the subtropical ridge.

The depression began to strengthen and was upgraded to Tropical Storm Iniki at 0300 UTC on the 8th. The tropical storm continued to intensify on the and increased its westward motion to near 12 knots as the subtropical ridge shifted southward. Iniki was upgraded to a hurricane at 0900 UTC on the 9th about 470 miles south southwest of Hilo. It was moving west northwest at 12 knots.

By 0330 UTC on the 10th, Hurricane Iniki was located 385 miles south southwest of Hilo generating maximum winds estimated at 85 knots.

Iniki was approaching the western edge of the subtropical ridge to the north. A large cold low and trough aloft began to dig southward along and just east of the International Dateline at the same time, causing Iniki to take a track slightly north of west. Meanwhile, the upper level flow pattern in the western Pacific continued to change as a series of short waves dug the long wave trough southward along the dateline. The subtropical ridge appeared to be weakening west of 160°W with southwesterly flow increasing on the east side of the upper trough and it appeared that this eventually turned Iniki on a more northward track.

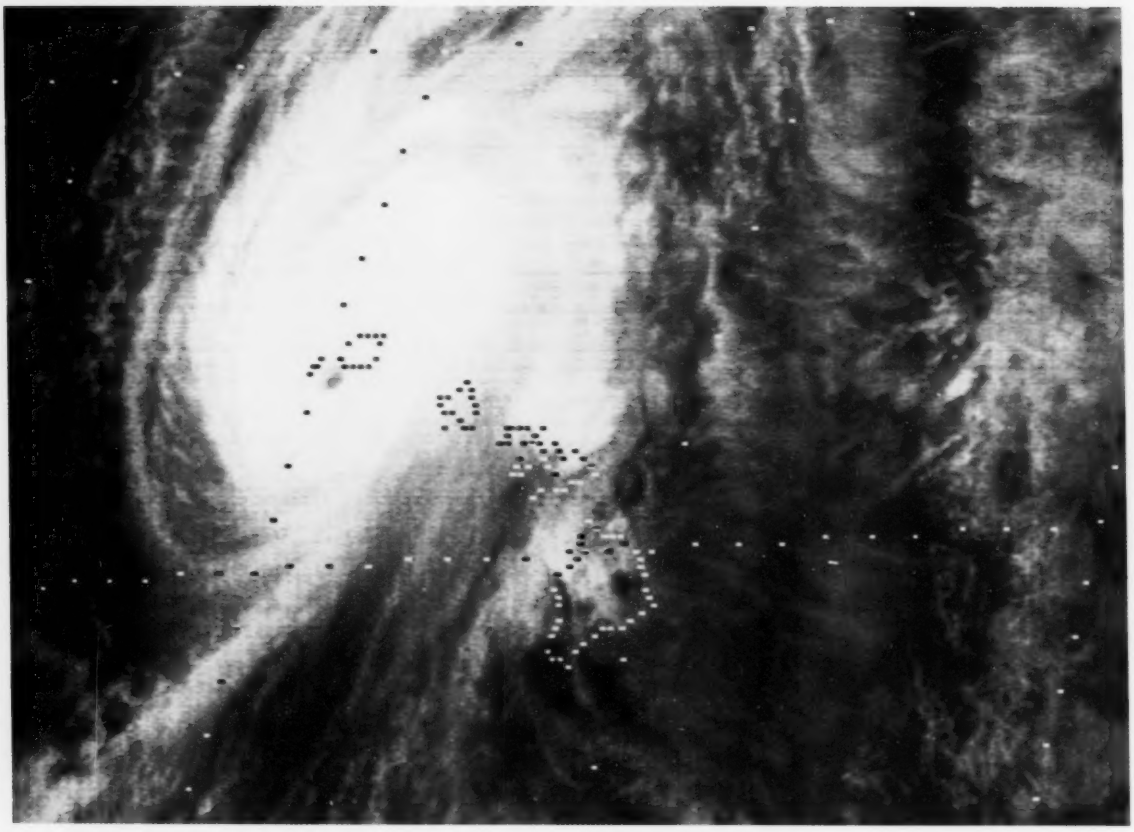
Iniki began to slow during the morning hours of the 10th by 2100 UTC was located 425 miles south of Honolulu and still moving west at 10 knots. Reconnaissance (recon) aircraft reported top winds of 100 knots and a central pressure of 951 millibars. Iniki slowed even more and started to turn northwestward. At 0300 UTC on the 11th, its center was about 400 miles south of Lihue, Kauai and maximum winds were now estimated to be 110 knots with gusts to 135 knots. A hurricane watch was issued for the western Hawaiian chain from Kauai and Niihau, westward to French Frigate shoals. An intermediate advisory at 0630 UTC issued hurricane warnings for Kauai and Niihau, and tropical storm warnings for Oahu. A tropical storm watch was issued for the islands of Maui, Lanai, and Molokai. High surf advisories were continued for all of the Hawaiian chain.

By 2100 UTC on the 11th, Iniki was 130 miles south southwest of Lihue moving northward at 15 knots. The maximum sustained winds were estimated at 125 knots with gusts to 150 knots. The recon flight measured a central pressure of 938 millibars (lowest pressure ever recorded in a central Pacific hurricane) using a dropsonde and maximum flight level winds of 135 knots making this the most intense period of the storm's life.

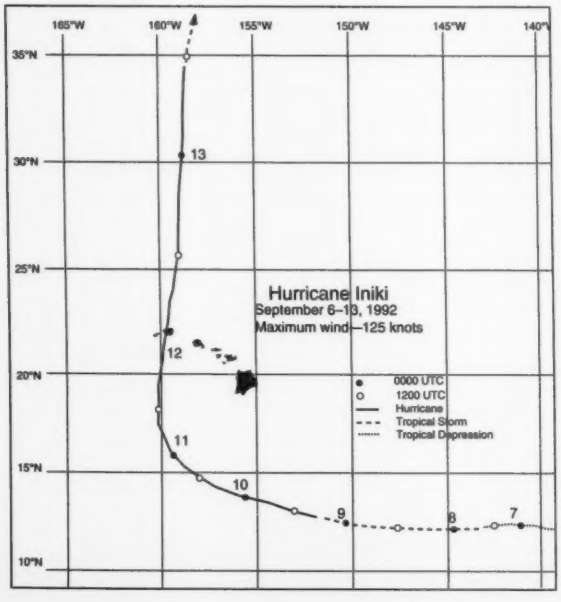
Iniki was rapidly approaching the Kauai coast and by 0100 UTC on the 12th was located near 21.6°N, 159.7°W, or 37 miles southwest of Lihue. The reconnaissance report at the time indicated a central pressure of 945 millibars and max flight level winds of 127 knots. The eye of Iniki passed over Kauai as it continued to accelerate. The center was moving northward at 25 knots and by 0300 UTC was centered about 50 miles north of Kauai.

Iniki continued to move northward and weaken. By 2100 UTC on the 12th, it was located 500 miles north of Kauai, with top winds near 80 knots and gusts to 100 knots. Iniki decreased to tropical storm strength by 1500 UTC on the 13th near 36°N, 158°W. It was becoming extra–tropical while merging with an approaching low pressure system and cold front.

Damage was extensive throughout Kauai. Ocean damage was heaviest along the south shore of Kauai and affected shoreline hotels and condominiums, especially around Poipu. Wind damage was extremely heavy throughout Kauai, as many homes or



Hurricane Iniki at about 0100 UTC on the 12th of September. Its center was located near 21.6°N, 159.7°W, or 37 miles southwest of Lihue. The reconnaissance report at the time indicated a central pressure of 945 millibars and max flight level winds of 127 knots.



buildings were flattened or lost their roofs. According to Red Cross figures, Iniki left 14,350 damaged or destroyed homes on Kauai. The number of homes that were completely destroyed was 1,421. A total of 63 homes were destroyed by waves and storm surge on the south coast of Kauai. The number suffering major damage was 5,152, and 7,178 suffered minor damage. Electric power and telephone service were lost throughout the island and only 20 percent of power had been restored 4 weeks after the storm. Crop damage was likewise extensive, as sugar cane was stripped or severely set back, while fruit trees were broken or uprooted. The monetary value of the damage caused by Iniki on the island of Kauai was estimated at $1.8 billion.

The areas most affected on Oahu were the leeward coast from Barbers Point through Makaha and Kaena Point, with lesser damage along the south shore from Ewa Beach to Hawaii Kai. Some damage also occurred on the islands of Maui County and the Big Island of Hawaii, where swell and heavy surf from a

CENTRAL NORTH PACIFIC TROPICAL CYCLONE SUMMARY, 1992*

Name	Dates	Highest Classification in Central Pacific	Max Winds (KT)	Min Observed SLP
Ekeka	28 Jan - 4 Feb	Hurricane	E100 (SFSS)	N/A
Hali	28-30 Mar	Tropical Storm	E45 (SFSS)	N/A
Frank	21-23 Jul	Tropical Storm	E45 (SFSS)	N/A
Georgette	24-28 Jul	Tropical Depression	E30 (SFSS)	N/A
Javier	7-12 Aug	Tropical Storm	E40 (SFSS)	N/A
Iniki	5-13 Sep	Hurricane	125 (RECCE)	**938 MB
Orlene	12-14 Sep	Tropical Depression	E30 (SFSS)	N/A
Roslyn	24-30 Sep	Hurricane	E65 (SFSS)	N/A
Tina	9-11 Oct	Tropical Depression	E25 (SFSS	N/A
Yolanda	22-23 Oct	Tropical Depression	E25 (SFSS)	N/A
THREE-C	21-22 Nov	Tropical Depression	E30 (SFSS)	N/A

NOTES:
* Data pertains only to period when tropical cyclone was in the Central Pacific
** SLP determined by dropsonde

southwesterly direction pounded exposed shorelines and anchorages.

There were six deaths connected to the storm. One woman on Kauai died of a heart attack when a portion of her house fell on her, a man was killed by flying debris when he was out during the storm, two Japanese nationals drowned when their boat was capsized in waters off of Kauai, one person died on Oahu when his residence was set on fire by a candle being used for light, and a National Guardsman was killed when his truck over turned while trying to avoid live wires during the post storm cleanup. More than one hundred people were injured, some after the storm when the cleanup began.

Hurricane Ekeka
January 28 – February 4, 1992

Hurricane Ekeka was a rare out-of-season tropical cyclone that formed close to the equator in the vicinity of Christmas Island. This was the first central North Pacific hurricane observed during the month of January since the advent of weather satellites in the 1960s.

Ekeka formed within a large area of deep convection close to the equator that had been observed by satellite for a number of days. Several ship reports as early as January 23 had indicated squalls and strong southwesterly winds just north of the equator to the south and southeast of the Hawaiian Islands.

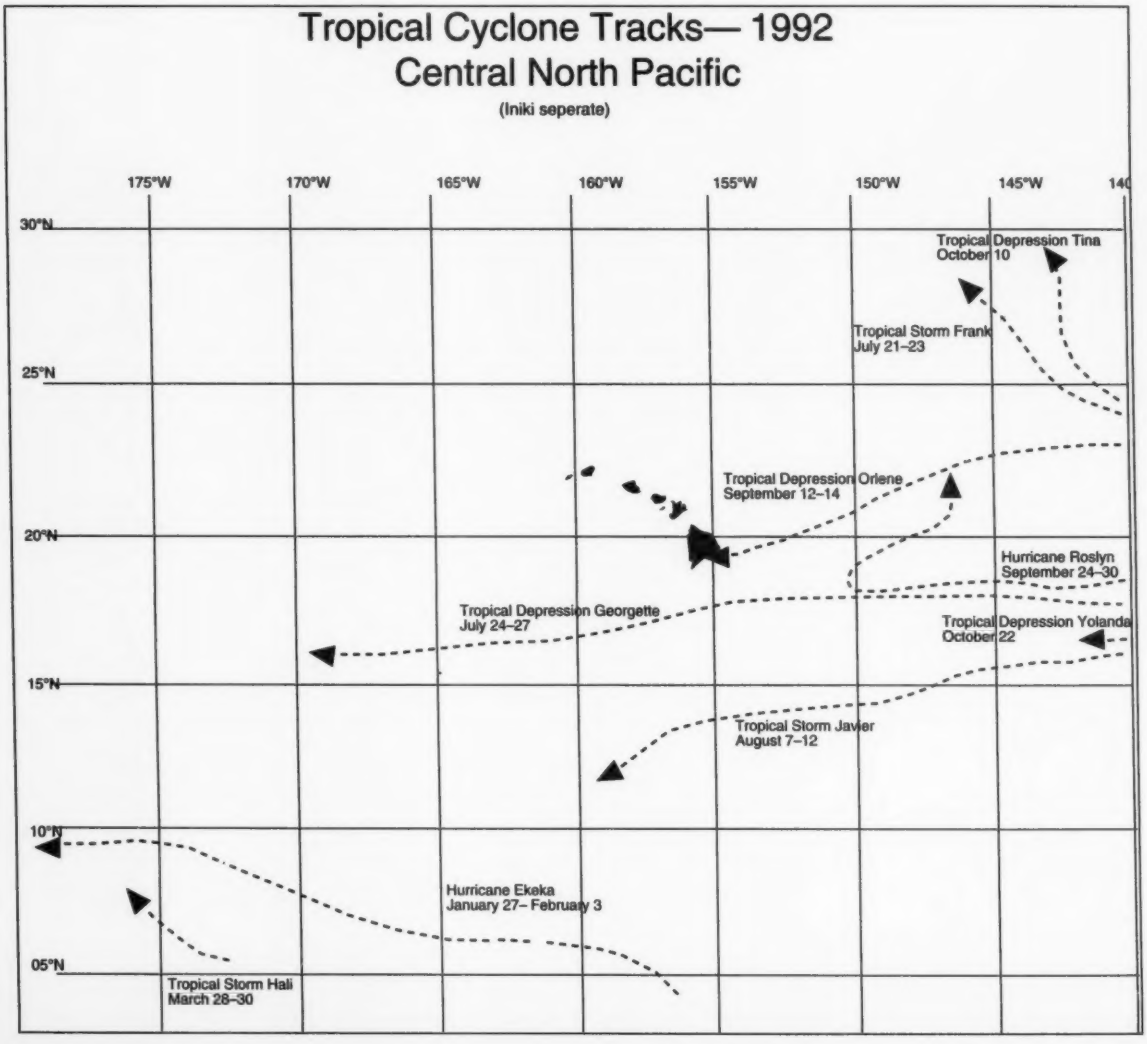
The first advisory on Tropical Depression One-C was issued by the Central Pacific Hurricane Center (CPHC) at 0900 UTC on the 28th with the center just north of Christmas Island and just east of Fanning Island. One-C intensified rapidly and became tropical storm Ekeka (Hawaiian for Edgar). Ekeka was upgraded to a hurricane at 0000 UTC on the 30th as it moved slowly west northwestward remaining well south of Johnston Island. An estimated peak intensity of 100 knots was reached on February 2 with Ekeka nearing 10°N, 175°W. A large trough in the upper level westerlies began to have detrimental effects on the hurricane as it neared the dateline on February 4. Vertical wind shear caused Ekeka to lose strength rapidly and the system was barely of tropical storm intensity when it crossed into the western Pacific near 09°N, 180° at1800 UTC on the 4th.

The Joint Typhoon Warning Center downgraded the weakening tropical storm to a depression at 1200 UTC on the 4th. The depression continued to move westward through the Marshall Islands and did not cause any known problems.

Tropical Storm Hali
March 28–30, 1992

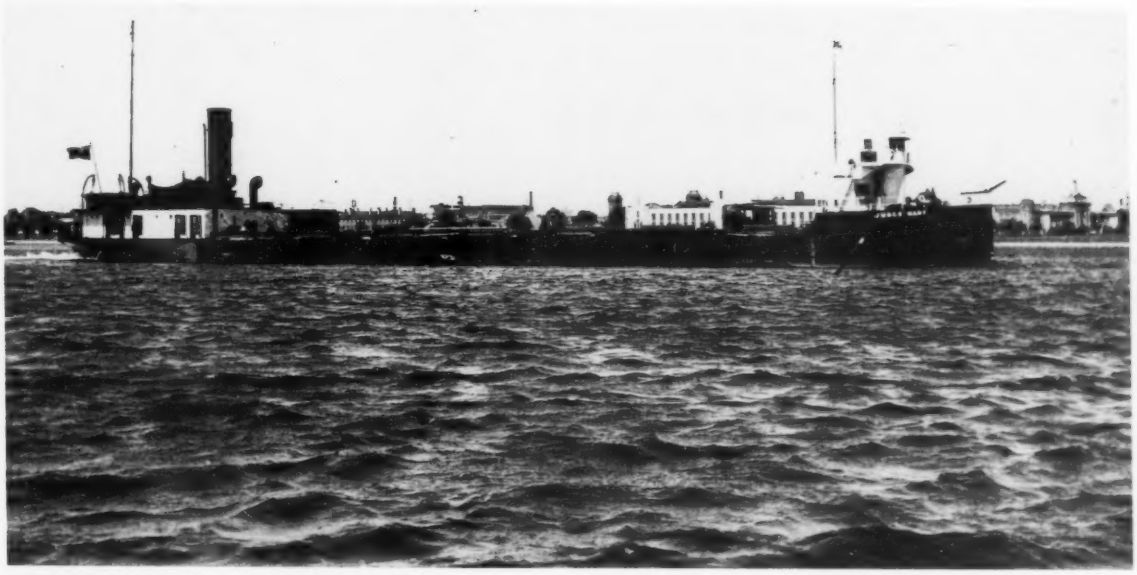
Warm equatorial water south of the Hawaiian Islands early in the year had the effect of producing some very active convection and heavy rains along the equator from the dateline eastward to the coast of South America. This is typical *El Nino* weather during the Northern Hemisphere autumn and winter months when the otherwise sunny and dry Line Islands get inundated by torrential rains and the pleasant trade winds are replaced by humid westerly winds. These conditions are also conducive for the development of tropical cyclones.

Hurricane Ekeka formed within this area of heavy convection in late January near Christmas Island. This very unseasonable tropical cyclone activity repeated itself in late March as Tropical Depression 02–C developed on the 28th within a cluster of deep convection near 05°N, 170W°. The depression intensified slowly and was upgraded to Tropical Storm Hali (Hawaiian for Holly) on March 29. Hali peaked at about 45 knots in the area near 07°N, 175°W on the 29th, then weakened rapidly and dissipated on the 30th as strong upper southwesterlies sheared its top off and caused the system to break up.



The *Judge Hart*

Skip Gillham



Today, the ***Judge Hart*** rests in 150 feet of water below Lake Superior, but in the winter of 1942 the small Canadian steamer managed to stay afloat long enough to keep the crew from the frigid November waters until they could be rescued.

The ***Judge Hart,*** a 261 long bulk carrier, was built for the Eastern Steamship Company at East Cowes, on the Isle of Wight, and was launched April 21, 1923 and sailed for the Great Lakes. The 1,729 gross ton vessel was later sold in 1936 to the Upper Lakes and St. Lawrence Transportation Company and operated in their service when it was lost.

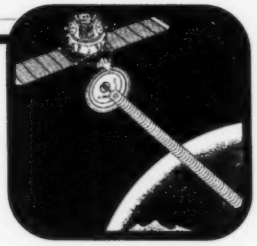
On its last voyage, the ***Judge Hart*** sailed from Port Arthur, Ontario with a load of grain and headed for Toronto. Seeking protection from an impending storm, the Captain followed the north shore of Lake Superior enroute to Sault Ste. Marie. Visibility was seriously reduced by the blinding snow and assessing the ship's position was not an easy task for the Captain.

As conditions worsened, the Master chose to return to the safety of Jackfish Bay in northeast Minnesota. The ship groped along at slow speed with only a general idea of location. Soon ice froze the pilothouse doors closed. At about 1500 hours, on November 26th, the struggling ***Judge Hart*** ran aground on Fitzsimmons Rock.

The engine continued to run and held the ship in place in the surging seas. Two days later, on November 28th, the possibility of sliding back off their perch led to a decision to abandon ship. Another company ship, the ***James B. Eads***, was standing by and took the weary sailors on board. With no one to tend the fires, steam power was lost and the vessel slid back off the ledge, drifted and sank.

For nearly 50 years the ***Judge Hart*** rested on beneath Lake Superior's waters. The wreck was finally discovered by divers on June 16, 1990. The ship is in about 150 feet of water and is reported to be in excellent condition.

The photograph of the ***Judge Hart*** was taken by John.H. Bascom when the vessel was docked in Toronto, Ontario in September 1938.



Estimating Ocean Surface Currents

L.C. Breaker, J.W. Clark and V.M. Krasnopolsky

Measuring ocean surface currents has been a difficult problem historically. Ship drift has been the primary source of information on surface circulation, but such observations are fraught with uncertainty. Because reliable measurements of surface currents are not easy to acquire, more recent remote sensing techniques such satellite feature-tracking are assuming greater importance. Satellite feature-tracking is based on comparing successive satellite images which are spatially aligned to determine the changes in feature locations which have occurred. Unique surface features which appear in both images are usually displaced due to the influence of the prevailing surface currents. By measuring these displacements and then dividing by the time interval between the images, we are able to obtain estimates of the surface flow. To measure feature displacements, the precise locations of the features in each image must first be determined. The actual displacements are then determined from simple calculations. Sea surface temperature is usually the physical property that is used to trace the flow although ocean color has also been used for this purpose. The technique of feature-tracking is simple in concept, however, it is not as simple in practice to implement.

The method described is almost identical to that which has been used by meteorologists since the late 1960's to estimate low level winds using sequential imagery from the geostationary satellites. For the ocean, however, the problem is more difficult because the features of interest often move only short distances between images. Thus, the accuracy with which we can earth-locate ocean features becomes a critical factor in our ability to obtain reliable estimates of the surface flow. Also, the time interval between the images becomes an important consideration. If the time separation is too short, then the feature displacements may be too small to measure accurately. If the time separations are too long, then the features begin to loose their identity and they become difficult to track.

At right is an example of surface flow estimates obtained from feature-tracking.

Satellite feature-tracking offers the potential for providing information on surface currents over relatively large ocean areas on a regular basis. To date, the primary application for this technique has been in coastal areas where the satellite imagery can be more accurately earth-located due to the availability of landmarks. It is anticipated that within the next year, NOAA will begin producing experimental surface current analyses for a selected region off the U.S. East Coast. Your interest in this project can be expressed by contacting:

NOAA
(Director, National Meteorological Center
World Weather Building
520 Auth Road
Camp Springs, Maryland 20746)

Two images from the Advanced Very High Resolution Radiometer aboard the NOAA-11 polar-orbiting satellite acquired approximately 12 hours apart on the 24th of June 1991 were used in this feature-tracking analysis above. The region shown extends from 37N to 41N and from 69.5W to 74.W. The surface flow vectors were produced in the Slope Water region that lies between the Gulf Stream to the southeast and the continental shelf to the northwest. Current speeds ranged from about 10 to almost 50 cm/sec. The prevailing direction of flow was to the southwest in general agreement with the climatological circulation in this region.

Rescue of the Jamaica

Elinor De Wire
Mystic Seaport Museum

In mid-July of 1885, the ship ***Jamaica***, bound for Chicago with a load of coal, left Oswego, New York and made its way into Lake Michigan. Its crew of seven were accompanied by the captain's wife, his nine-year-old son, and his young niece. The trip was blessed with fine weather and a good breeze that pushed the schooner gently toward its destination. It seemed like the perfect passage until the morning of August 2nd when the Jamaica sailed straight into a storm that would endanger all their lives.

All that day the crew worked to hold the vessel against the wind and waves, but by late afternoon it had sprung a leak in the rudder casing. The pumps could not keep up, and a stout wind tore the foresail, boom, and gaff away, leaving the ***Jamaica*** powerless and drifting aimlessly. As the fury increased, the captain ordered his wife and the children taken aloft and lashed to the crosstrees. The crew soon followed, and not a moment too soon. Not long after dark, the ***Jamaica*** struck the beach a mile north of Glencoe, Illinois.

The nearest rescuers were 8 miles from the wreck site. Surfmen from the Grosse Point Lifesaving Station at Evanston were patrolling the beach that night, walking 2.5 miles in either direction. The patrols were unable to see the ***Jamaica*** as it lay foundering, but as the north patrolman reached the limits of his beat near dawn, he noticed huge wooden posts washing ashore. Storm spray obscured visibility, but he suspected a ship was ashore farther up the lake and hastened back to the station with the news.

Due to poor roads and bad weather, it took the crew 2 hours to reach the scene of the wreck ...

In the meantime, a telegraph message concerning the wreck made its way from Glencoe to Evanston, then it was hand carried to the lifesavers at Grosse Point. But the message had been scrambled, and Head Keeper Lawrence Lawson knew only that a ship was wrecked. He gathered a few crewmen and headed to the lighthouse where he could use his spyglass to scan the lake from the lofty lantern. It was a worthwhile decision, as the Jamaica's masts were quickly spotted.

By 10:00 a.m. the head keeper and his crew were back at the station harnessing the horses to the beach cart. "The spirited animals seemed to understand, as well as the men, the pressing needs of the moment and sprang forward on the road to rescue like mettled chargers," read a government report of the effort.

Due to the poor roads and bad weather, it took the crew almost 2 hours to reach the scene of the wreck and clear away a place to set up the beach apparatus. A crowd of local people, including the lighthouse keepers and their families, had already assembled to lend hands and to erect an optimistic sign for the shipwrecked

U.S. Coast Guard

Grosse Point Lifesaving Station stood guard on the shore of Lake Michigan near Evanston in this 19th century photograph. The crew of the station, established in 1876, always included a few students from Northwestern University. Students and faculty were known to pull foundering swimmers and seamen from the water, and they continued to work with the Lifestation until the Coast Guard took over in 1916. The lifesaving station which was part of the University grounds stands no longer.

crew that read: HELP COMING!

Rescue by boat was impossible, due to the high bluffs and the heavy seas around the vessel, so the surfmen chose to use the breeches buoy to bring the crew ashore. No one had perished aboard the vessel, but time was running out. With each rush of sea over the deck, the ***Jamaica*** shuddered and creaked, its hull splintering and its masts held upright only by their shrouds.

A surfman was sent out to the wreck in the breeches buoy to oversee the actual rescue.

The Lyle gun was positioned on the bluff some 80 feet above the lake, and a line fired. On the first try it fell across the jibboom within a few feet of the weakened crew. The whip was hauled aboard but there followed a few moments of despair as the lines were fouled while sending off the hawser. Crews at each end worked for an hour untangling the lines.

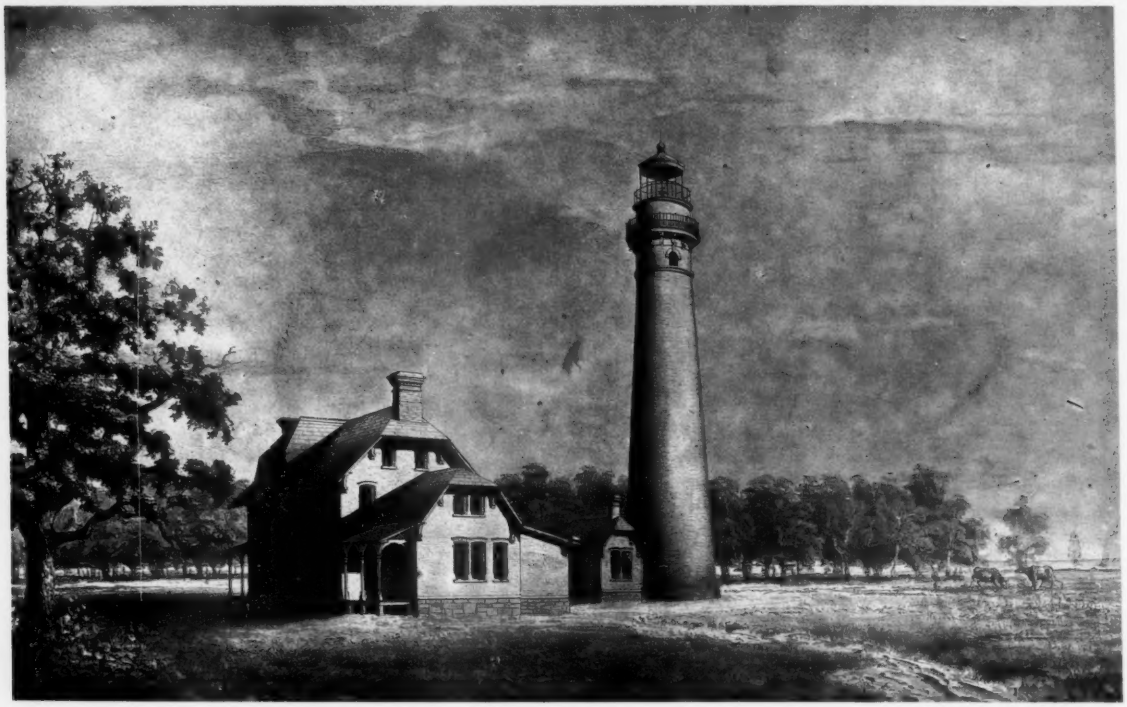
A surfman was sent out to the wreck in the breeches buoy to oversee the actual rescue. First to ride across the waves to safety were the mate with the captain's son in his lap, bouncing up and down and thoroughly soaked upon arrival. The steward and the captain's niece were next, then the captain and last his wife. The last man was brought to shore at 1:15 p.m.

The survivors were quickly taken to shelter, but the lifesavers remained on the beach another 5 hours, determined to retrieve their precious gear from the Jamaica. When all efforts failed, one surfman bravely rode the breeches buoy back out to the wreck and climbed aboard the battered ship to unfasten a snagged line. The men hated to give up anything to the water, even a rope.

The next day the lifesavers returned to the site to salvage whatever they could from the ***Jamaica***. It had gone to pieces, however, and all that was recovered was the anchor, some chain, a bit of sail and rigging, and part of the cargo. Everything but the sodden coal was sold to a junk dealer.

The Grosse Point lifesaving crew received great acclaim for their work on this occasion, but they were given the ultimate honor 4 years later when they rescued the entire crew of the wrecked steamer ***Calumet***. A November blizzard had disabled the vessel, yet the surfmen were able to launch the lifeboat three times in subzero weather to bring ashore all eighteen survivors.

A government report later noted that "flying spray from every wave-crest left a glaze of ice on every object it struck, the men's clothing being covered, while the oars were constantly slipping from the rowlocks...." Each man at the



Am. Photo—Relief Printing Co.

Grosse Point Lighthouse, in the northern Chicago suburb of Evanston, stands on land first used by the Potawatomi Indians and later awarded to Archange Ouilmette, the Indian wife of a French trader. Ouilmette was forbidden to sell the land without the consent of the president of the United States. The treacherous shoals that extended 2 1/2 miles led to the building of the lighthouse in 1873. It was decommissioned in the 1930s, but a lightkeeper still lights the tower and watches over the park lands below. Two small buildings once used to fire up steam powered fog horns today house the Evanston Ecology Center which provides education on environmental issues to area schools.

Grosse Point Station was awarded a gold lifesaving medal for his effort.

... the crew always included a few college students because the station stood on the campus of Northwestern University.

From its establishment in 1876 and up until the Coast Guard took over the Grosse Point station in 1916, the crew always included a few college students because the station stood on the campus of Northwestern University. It was a natural site: Students and faculty had been pulling foundering seamen and swimmers from the lake since the university's beginning.

A lifeboat was given to the university in the 1850s as a result of students' fearless rescue of 17 passengers from the wrecked ***Lady Elgin.*** When the U.S. Lifesaving Service formed in 1871, the campus was dubbed an ideal site for a lifesaving station. A handsome house with a lookout tower was built and a professional keeper was hired to manage the station. Willing crews, ready to assemble whenever the alarm sounded, were drawn from the student body and the town.

Their heroism made the halls of Northwestern University shine all the brighter – aided, of course, by the beam of nearby Grosse Point Lighthouse and the surfmen's intrepid hymn, sung on Sundays in Evanston churches:

Trim your feeble lamp, my brother;
Some poor seaman tempest-tossed,
Trying now to make the harbor,
In the darkness may be lost.
Let the lower lights be burning,
Send a gleam across the wave;
Some poor fainting, struggling seaman,
You may rescue, you may save!

Weather Buoys—Keeping an Eye on the Coast

Debi Iacovelli

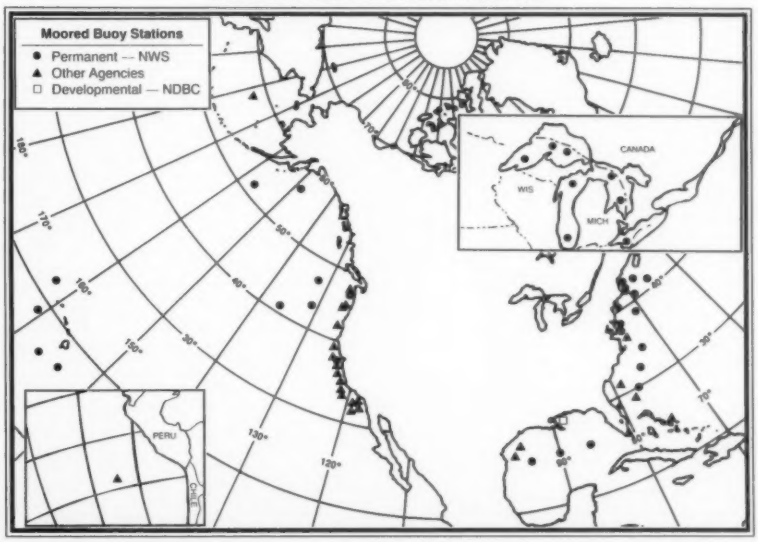
The need for surface observations from data-sparse marine areas worldwide becomes even more critical when coastal areas are threatened by a landfalling hurricane. What happens when a major hurricane threatens the coastal U.S? What can be done to provide effective weather forecasts that may ultimately save life and property?

To fill this need, the National Data Buoy Center (NDBC) in Stennis Space Center, Mississippi operates over 110 moored buoys and Coastal-Marine Automated Network (C-MAN) observation stations to acquire data for weather forecasts, warnings, and analyses. NDBC coverage stretches from Hawaii through the Gulf of Alaska, down the West Coast to Southern California, across the center of the Gulf of Mexico and up the east coast to the Gulf of Maine. In addition, their network of approximately 35 drifting buoys are used for research programs and hurricane investigations. Data from the NDBC is also used for research projects such as wave generation and propagation, coastal ocean circulation analyses and modeling, and marine boundary layers. NDBC's weather buoy and C-MAN station reports not only provide dependable observations for daily weather analyses and forecasts, but they also provide ground truth for measurements taken by satellites thus becoming an integral part of the hurricane-warning system. They are the only means, to date, of making nearly continuous, single-point, direct surface measurements over the oceans.

There are several types of moored buoys: 6-meter boat shaped NOMAD or Navy Oceanographic and Meteorological Automotive devices for deep-ocean deployment can survive the most severe weather environment, 12-meter discus buoys are built for harsh environments like the Bering Sea and Great Lakes except during the ice season, 3- and 10-meter discus buoys reside in the Gulf of Mexico and coastal areas. These buoys are moored by a chain or chain and nylon line to anchor on the ocean bottom in depths ranging from about 15 to more than 5,000 meters. There are 33 buoys in the moored buoy network that is directly funded by the National Weather Service; however, data from these and 32 other buoys funded by other agencies are available in real time to forecasters.

The C-MAN network was

NDBC BUOY LOCATIONS

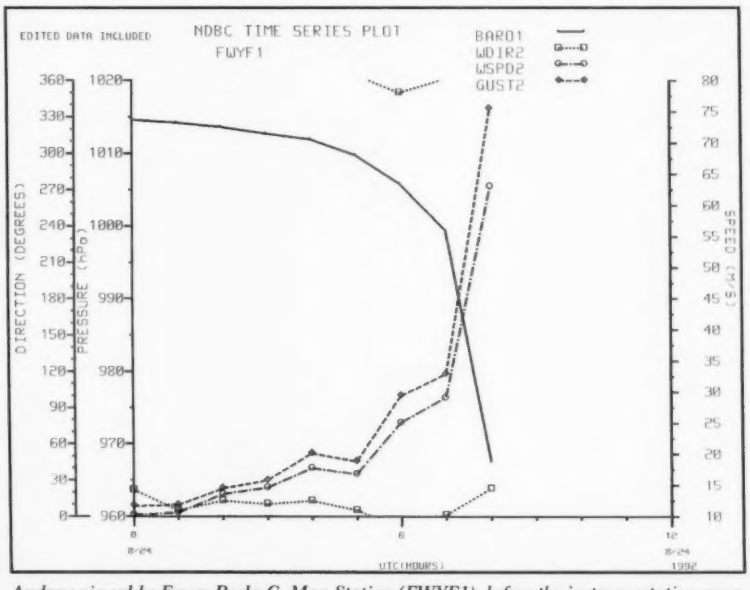


established in 1981 in response to the need for more coastal observations. This network consists of seven United States Coast Guard large navigational buoys which have been instrumented by the NDBC, along with 52 fixed stations located on beach areas, offshore oil platforms, exposed fishing piers and Coast Guard lighthouses.

Drifting buoys are used to obtain data from areas too remote or difficult to reach on a regular basis. Drifting buoys are not moored to the ocean bottom but drift freely in response to currents, tides and winds, collecting data for up to 18 months. The buoys use about 1 watt of power, and the supply in the air-depolarized, carbon-zinc primary batteries is sufficient for at least one year of continuous operation of sampling data and transmitting messages.

For the data from drifting buoys to be meaningful, their location must known. These 200-300 pound platforms transmit environmental data via NOAA Polar Orbiting Environmental Satellites and the National Environmental Satellite Data and Information Service (NESDIS) Command and Data Acquisition Site at Wallops Island, Virginia. It is then sent to the U.S. ARGOS Global Processing Center in Landover, Maryland. Service ARGOS determines the buoy's position by measuring the Doppler shift of the transmitted signal. At ARGOS, the data are coded, formatted, and routed through the National Weather Service Telecommunications Gateway (NWSTG) in Silver Spring, MD for dissemination to users in the U.S. and overseas. Data from the moored buoys and C-MAN stations are transmitted hourly through GOES satellite to NESDIS, then NWSTG receives the data, encodes it, and sends it to various data users.

The use of these automated weather platforms are invaluable in hurricane observations and investigations. In August 1992, Fowey Rocks C-MAN station (FWYF1) was in the direct path of Hurricane Andrew. The Category 4 hurricane blew out all the glass in the structure, and some of the weather equipment on this C-MAN station was either destroyed or damaged. The intense winds bent the 30- foot



Andrew viewed by Fowey Rocks C-Man Station (FWYF1), before the instrumentation gave way. The elements traced by NDBC are pressure (BARO 1), wind direction (WDIR2), wind speed (WSPD2), and peak (5 second) wind gusts (GUST2).

John C. Stennis Space Center

Fowey Rocks C-MAN station still stands after Hurricane Andrew. However, note the bent mast. The station is located on Fowey Rock Light.

high trolley mast that held the sensor cross arm, anemometers, and remote barometer port. The mast was bent 90 degrees to the West approximately 5 feet above its base. Although Fowey Rocks took the brunt of Andrew, it measured wind speed and direction, peak winds, sea level pressure and temperature until the station failed due to the intensity of the hurricane. Wind speeds were clocked to 140 mph (2 minute average) with a second 5-second peak wind to 169 mph. This was the second highest wind ever measured by a ground station in an Atlantic hurricane. This data helped forecasters verify meteorological information gathered from radar, satellites and reconnaissance aircraft that morning, along with providing data for further research after the storm.

When the U.S. is faced with a major hurricane, the National Hurricane Center (NHC) can request four drifting buoys from the NDBC to be placed in the path of a hurricane. Although this scenario may sound ideal, it doesn't happen often due to the rarity of a landfalling hurricane and the lack of preparation time. The track of the storm also needs to be predictable, as a 36- to 48-hour notification is required. The buoys are deployed, using the Air Force Reserve (AFRES) C-130 aircraft, between 100 to 180 nautical miles from the storm's center. In October 1984, three drifting buoys were air-deployed into the path of Hurricane Josephine. These buoys, equipped with a anemometer, pressure sensor, and underwater sensors reported reliable data during the storm's high winds and rough seas.

The NDBC has plans for future expansion of its automated weather platform network of moored buoys, C-MAN stations, and drifting buoys. Data from these platforms have been an important part of marine forecasting and warnings and equally important to the study of atmospheric wind fields in hurricanes.

Acknowledgements: I would like to thank Eric A. Meindl and Michael Burdette of the NDBC and the NDBC Graphics Department for their kind assistance.

Portions of this article have appeared in the ***American Weather Observer*** *(AWO), the monthly journal of the American Association of Weather Observers. Debi writes their Tropical Topics column.*

More About Buoys

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What are Drifters?

Laurence Sombardier

Voluntary Observing Ships (VOS) are playing an increasingly important operational role in scientific research with the collection of oceanographic (XBT) and atmospheric data in the open ocean. The data are incorporated into computer models which are used to predict weather changes ranging from daily variations to global climate changes such as the El Niño phenomenon. Another scientific program which is now strongly dependent on a close cooperation with volunteer ships is the Surface Velocity Program (SAVP) –a coordinated, world-wide effort to obtain new and accurate data with freely drifting buoys measuring ocean surface currents, sea surface temperature (SST), sea surface salinity (SSS), and sea level air pressure.

Since the time of Matthew Fontaine Maury, commercial vessels have contributed to much of our present knowledge about the world's surface currents by providing information on how ships drift off course. By the end of the 19th century, geographers had mapped all the major western boundary currents and tropical ocean current systems. In turn, ships have saved precious time by using the published current charts in conjunction with marine weather forecasts.

Because ships sail primarily on great circular routes between major ports, even today we don't have enough ship-drift data to make realistic surface-current maps for almost 80 percent of the ocean surface. In addition, the drift of a ship is affected by wind and waves as well as the average current below the waterline. This results in an uncertainty in a drift of up to 0.5 knots, or 25 centimeters per second, which is faster than the surface circulation of most of the ocean. This can be likened to a wind speed estimate that varies by 15 to 20 knots. The urgent need for accurate current measurements led to the development of the satellite-tracked SVP Lagrangian Drifter which commercial vessels have been releasing for a number of years in all major ocean basins.

The standard SVP drifter consists of a 35-centimeter diameter fiberglass surface float which houses the ARGOS transmitter, batteries to last 2 years, a sea surface temperature sensor, a smaller subsurface float (to minimize the impact of the surface ocean waves on the motion of the buoy), and a Holey Sock drogue (a cylindrical shell of Cordura nylon, the center of which is 15 meters below sea surface). Polar orbiting satellites determine the location of the drifters using the ARGOS tracking system; the accuracy of the location fixes is typically 500 meters. Location information along with sea surface temperature measurements is sent back to NOAA and is then relayed to GTS (Global Telecommunications System). Certain drifters are adapted with pressure ports and salinity sensors as well as the standard SST sensor.

A wide variety of drifting devices have been invented and used in the past, most of which had poor

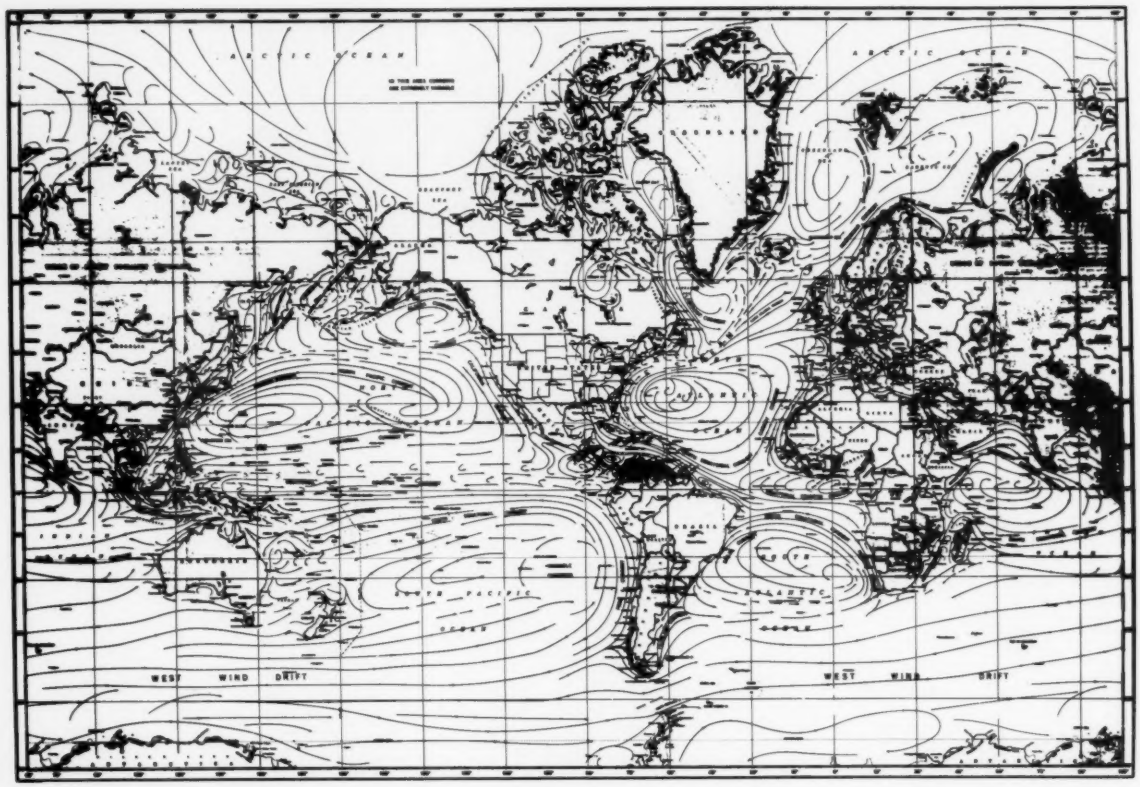
Laurence Sombardier is the manager of Global Drifter Center at Scripps Institution of Oceanography in La Jolla, California.

The author models the Holey Sock drogue. The SVP Drifter was designed at Scripps Institution of Oceanography to be low cost, easy to manufacture, and deploy. It was important that it have a known water-following capability and be durable at sea for more than a year. The surface float is a 35-centimeter diameter fiberglass sphere that houses the ARGOS satellite radio transmitter, antenna, batteries, sea-surface temperature sensor, and a submergence sensor that reveals whether the drogue is still on or has fallen off. A polypropylene-impregnated wire tethers the float to the drogue 15 meters below.

or unknown water following capabilities. The SVP drifter, on the other hand, has been thoroughly tested at sea. The goal was to design an instrument which would follow currents without being affected by wind or wave forces. By reducing the size of the surface float and tethers and enlarging the drogue, we have developed a drifter that follows water motion to an accuracy of 1 centimeter/second in winds of 10 meter/second. In addition, continuous tests and evaluations have led to a series of technical improvements which have increased the average half-life time of the drifter to over 450 days.

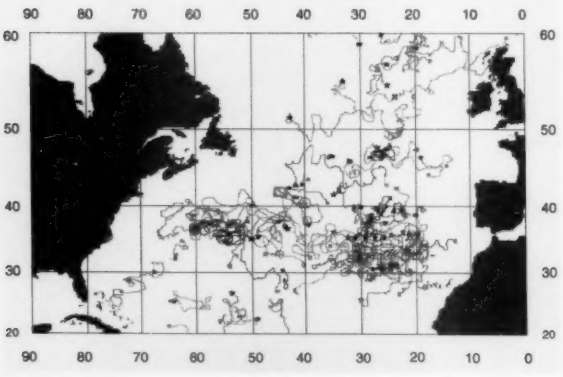
For ease of handling, the Holey Sock drogue is folded into an accordion that is held together by paper tape. The tether is coiled around a cardboard cylinder and the magnet whose removal switches on battery power through the surface-float hull is also attached with paper tape. The SVP drifter weighs about 60 lbs. in air, so one able-bodied seafarer can easily throw it it in the water from the stern of a vessel at full speed. After a few hours in the water, the paper tape dissolves, the drogue deploys itself below the surface float, and the magnet falls off, initiating satellite transmission through ARGOS. Holey Sock drifters are regularly deployed by oceanographic research vessels, aircraft, and VOS.

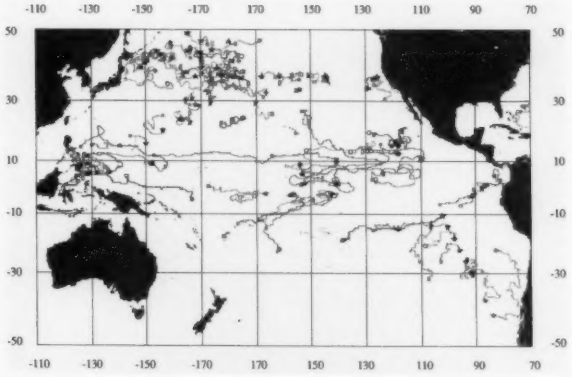
Systematic deployments of our drifters began in the Tropical Pacific in 1988 for the Tropical Ocean and Global Atmosphere Program (TOGA). Mid-latitude Pacific Ocean deployments for the World Ocean Circulation Experiment (WOCE) started in 1991. Over 1,000 drifters have been deployed to date. An array of 420 drifters is to remain in the Pacific for an indefinite period of time in support of El Niño prediction efforts. Deployments in the North Atlantic started in 1992 and we plan to start seeding the Southern



Oceans and Indian Oceans by 1993 and 1994. The number of VOS deployments has drastically increased in the past 2 years as standard packaging and deployment methods were devised. These launchings correspond to one-third of our total deployments in 1992.

By the end of 1993, we expect that two-thirds of the deployments will be made from voluntary commercial ships. Wouldn't Maury be proud of this accomplishment.





The ocean currents of the World's oceans (at top of page) were published by the Defense Mapping Agency and are based in part on the ship drift data collected since the time of Maury. These represent the average current conditions for July, August, and September. The spaghetti diagrams or drifter tracks are shown above for all drifters deployed by VOS in the North Atlantic and North Pacific in 1992. After the WOCE/TOGA drifter program winds down in 1997, a more permanent array of drifters in the world's oceans is planned by the Global Ocean Observing System.

Tybee Lighthouse

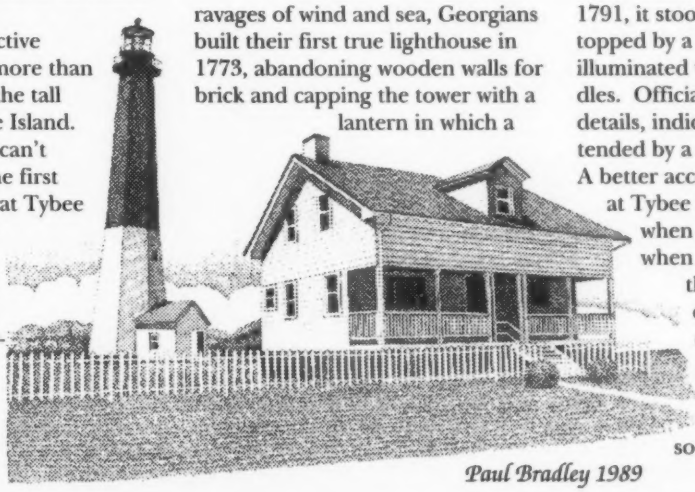
Elinor De Wire
Mystic Seaport

To give some hint of the size of their state, Georgians recite the phrase, "From Tybee Light to Rabun Gap." This near 300-mile stretch traces the twists and meanders of Georgia's most important river – the Savannah – and defines the state's northeastern border. Where the Savannah River opens to the sea is one of the South's most elegant and active ports, marked for more than three centuries by the tall lighthouse at Tybee Island.

Historians can't agree as to when the first beacon was placed at Tybee Island, but an official one was certainly in use by the American Revolution. Among Georgia's gifts to the fledgling Federal Government in 1791 was the brick lighthouse at the mouth of the Savannah River. General James Oglethorpe, founder of the Georgia Colony, had ordered a watch tower built on this site in 1736, but it was quickly destroyed by a storm. A second wooden tower was built in 1742, but it too was smashed by a gale, as was again its 1748 replacement.

Determined to outwit the ravages of wind and sea, Georgians built their first true lighthouse in 1773, abandoning wooden walls for brick and capping the tower with a lantern in which a candelabra burned each night. Tybee's feeble beacon joined a mere half dozen other lights in the colonies at this time, but it had the distinction of being the southernmost lighthouse and one of only two sentinels in the South. The other was at Charleston, South Carolina.

When Tybee Lighthouse came under Federal control in 1791, it stood about 90 feet tall, topped by a wooden lantern and illuminated with spermaceti candles. Official records lack further details, indicating only that it was tended by a keeper named Higgins. A better account of the happenings at Tybee Light came a year later when the tower caught fire when a candle dropped on the tallow-soaked wooden floor. The Savannah customs collector attempted to fight the blaze and later remarked: "... it was so very hot I was not able



Paul Bradley 1989

Tybee Lighthouse has withstood the ravages of weather and war for nearly 3 centuries at the point where the Savannah River opens to the Atlantic Ocean. Early 18th century Tybee lights were destroyed by wild ocean gales. During the Civil War, the Confederates decapitated the light with a well placed keg of dynamite. Today only 60 feet of base dates back to 1773, the remaining lighthouse was rebuilt in 1867 to its present height of 154 feet.

U. S. Coast Guard

to tarry half a moment and I saw it was in vain to attempt to save it."

Presumably, some of the brickwork survived the fire and was used in the construction of the new lighthouse. Wood was prudently rejected altogether, in favor of an iron lantern and stairs and iron window casings. Within a few years the beacon was fitted with 15 oil lamps and reflectors, as was the custom with most major estuary lights during the early 19th century. These were clean, hollow-wick Argand lamps intensified by Lewis's parabolic reflectors.

By the 1820s, commerce in and out of Savannah was burgeoning. Larger vessels found the river entrance difficult to navigate, necessitating the construction of a smaller sentinel, called the Tybee Beacon, not far from the main lighthouse. When its dimmer light was lined up underneath the Tybee Light, piggyback fashion, the two served as a range for ships entering the river channel.

In the 1850s, reorganization of the Lighthouse Service brought Tybee Light under serious scrutiny. A series of inspections revealed the United States to be far behind Europe in its lighthouse technology and listed many lighthouses in desperate need of repairs and improvements. Inspectors weren't in agreement as to Tybee Light's fitness for duty, but all felt it needed renovations.

Lieutenant David Porter arrived at Tybee Light in July 1851 aboard the Navy mail steamer ***Georgia***. Overall, he gave the light station a good review but suggested it be given a fixed light rather than a revolving light so as not to confuse it with the beacon at Charleston, South Carolina. He also felt a fog signal was needed:

"Tybee Light, though a very good one, cannot be distinguished in foggy weather. Tybee shows at a distance of 12 miles, which is quite sufficient, as the water is bold right up to the bay and the light and beacon show plainly before you reach the outer buoy. Tybee Light should also be provided with a steam whistle, or

Cockspur Beacon remains only as a landmark on nearby Cockspur Island, west of Tybee Light. One of two brick and mortar channel beacon lights, it was first lit in 1848, and its angled base was designed to cut the waves. At high tide its land base, resting on a bed of oyster shells, is completely covered with sea water. Like Tybee Lighthouse it too faced fire during the Civil War but this time from the Union Side. The Union Army found that they had to angle their guns very high in order to hit the targeted Fort Pulaski. Cockspur's beacons were saved by their diminutive height– only 46 feet high.

there should be a bell buoy on the bar, which is about 4 miles from the lighthouse."

The newly–formed Lighthouse Board, in its report to the government in 1852, did not concur with Porter's findings. The board suggested Tybee Light be raised to a height not less than 150 feet and given a first order Fresnel lens. It was described as "inferior" and placed on the board's list of lighthouses needing immediate attention. Only about 20 feet of additional height was added, however, and the board settled for a second order lens.

A decade of quiet followed, then in 1862 Confederate forces occupied the lighthouse. All of Savannah's beacons were extinguished, and in the struggle that ensued Tybee Lighthouse was burned and damaged by a gunpowder explosion. It stood dark until the end of the war. A hasty attempt to relight it was foiled by an outbreak of cholera. It was not repaired and relit until 1867. Workers used what remained of the old tower to build the handsome 144–foot structure that still stands today. Its current daymark clearly delineates where the old tower ended and the new one began.

It wasn't long before new problems beset Tybee Light. An 1870 inspection reported: "This light station is very unhealthy, which is mainly attributable, it is believed, to a small swamp which lies immediately in the rear of the keeper's dwelling."

Soon engineers discovered that a drain that had been dug years before had become obstruct-

ed during wartime operations, causing the swamp to fill and spawn an army of mosquitoes from the foul, stagnant water. A quick unclogging of the drainage system solved the difficulty.

A year later new troubles began. Cracks appeared in the tower walls after a severe hurricane. The inspector for that year warned that Tybee Light could "fall at any time" and recommended it be torn down and rebuilt. Five of the tower's eight faces had cracks, and they continued to widen over the next fifteen years. Though inspectors repeatedly stated the need for demolition and rebuilding, in subsequent years nothing was done. Another vicious storm in 1878 added to the damage, and in 1886 an unusual earthquake widened the cracks and broke the huge prism lens.

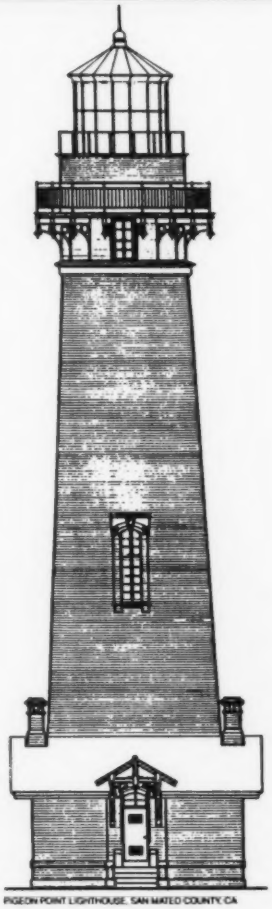
For some inexplicable reason, the government ignored all pleas to replace the tower, though concerns seemed well-founded, and the $50,000 proposal for a new structure would have put little strain on the Lighthouse Service's purse. Perhaps some perspicacious bureaucrat knew Tybee Lighthouse was as stubborn as its builders and firmly anchored to the Georgia shore. Despite its frightening scars, it hasn't fallen yet.

An interesting postscript to this august old sentinel's career is the story of Florence Martus, whose name has become synonymous with keeping a watch for the sailor returning home to Georgia. In 1883 her brother was appointed lightkeeper at the Elba Island Range Lights, about 6 miles inside the Savannah River. Along with the Tybee Island lights, these beacons assured large ships could make safe passage in and out of the bustling port at Savannah.

A gregarious teenager, Miss Florence often visited nearby Tybee Island Light and was the belle of Fort Pulaski, where her avid appetite for meeting people was satisfied by the history tours she gave to visitors. It was on one of these excursions that Florence became smitten with a handsome sailor from a ship that had stopped in Savannah for a few weeks. On the eve of his departure, the sailor asked Florence to be his wife and promised to return for her as soon as he could. He had no ring to offer, but instead he left her with his handkerchief, which she promised to wave from the shores of Tybee Island when he returned.

Weeks passed, then months, yet Florence heard nothing from her beau. She asked about him on the docks at Savannah, but no one seemed to know him or the whereabouts of his ship. Grief stricken, Florence began to wave the handkerchief at every ship that passed on the river. At first she waved in hopes someone would get word to her sailor that she desperately awaited his return, but as time passed and there was no news of him, her greeting to ships became a salve for her wounded heart.

Soon, sailors everywhere knew of the "Waving Girl of Elba Island," who beckoned them with a white handkerchief by day and swung a lantern to and fro at night. When her brother retired from lighthouse keeping in the 1930s, she had been waving to ships for more than 40 years. Though Florence died in 1944, she hasn't been forgotten nor have sailors lost their waving girl. A statue of her stands on the Savannah waterfront, her arm still upraised in an eternal greeting.



PIGEON POINT LIGHTHOUSE, SAN MATEO COUNTY, CA

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Gray's Reef National Marine Sanctuary

Justin Kenney

Once described as a "fertile oasis in the undersea Sahara of the Georgia coast," Gray's Reef National Marine Sanctuary stretches across 17-square nautical miles of Atlantic Ocean. Its relative isolation, 17.5 miles east of Sapelo Island, Georgia, draws experienced divers who make the 50-to 70-feet dive to the overhanging ledges and passageways that create an expansive maze above the barren ocean floor. The sandy, flat-bottomed troughs on the floor team with so much animal and plant life, it is called a "live bottom." Here, delicate sea fans and sea whips signal the changing currents where the Gulf Stream meanders to the coastal waters. Colorful sponges, sea stars, sea urchins cover the reef like so many blotches of color thrown on an artist's canvas. Small fish dart from hiding place to hiding place hoping to avoid the circling mackerels and barracudas while huge manta rays survey it all with an effortless ease.

Marine species adapted to either the warm Gulf Stream currents or the more temperate coastal waters can thrive in Gray's Reef. The sanctuary is a transitional area for many tropic and temperate species. The resulting diversity and abundance of species found at Gray's Reef, its location to shore, and its manageable size make it "a natural underwater laboratory" for scientists and explorers alike.

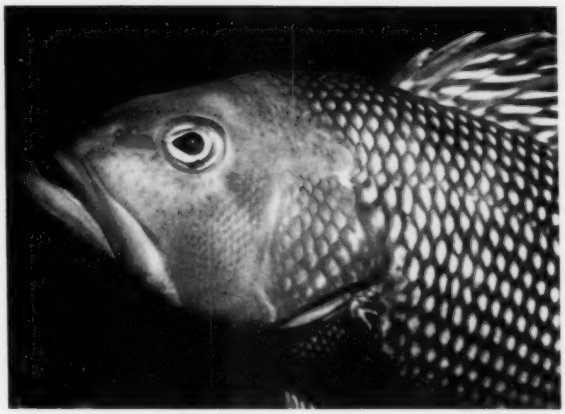
In fact, the reef received its name from a scientist who studied the reef in the 1960s, Milton B. Gray, a biological collector and curator at the University of Georgia's Marine Institute.

The evolution of Gray's Reef began some 5 million years ago during the Pliocene epoch. Marine sediments fell out of suspension and accumulated on the ocean floor, forming the limestone outcrops which now measure up to 6 ft. tall in places that are now the foundations of the reef. During the ensuing Pleistocene epoch or Ice Age, the rise and fall in sea level alternately exposed and covered the area while the forces of wind and water carved out the caverns and passageways seen today. As the Pleistocene epoch gave way to the Holocene epoch some 10,000 years ago, the scene at Gray's Reef looked considerably different and drier.

. Instead of large tiger sharks patrolling for red snappers or black sea bass, saber-toothed tigers roamed in search of giant sloth or mammoths. With large amounts of Earth's water still frozen within glaciers, the sea level 15,000 years ago stood 150 feet below today's level. Gray's Reef was then located some 40 miles inland, making it a better candidate for a National Park than a Marine Sanctuary.

The lower sea level also allowed for the introduction of humans to the area, probably crossing the Bering land bridge between Siberia and Alaska. As the sea level began its rise to the present level, Gray's Reef took on many different stages—inland forest, nearshore estuary, beach, and eventually submerged reef. Some archaeologists suspect that the gradual rise in sea level over thousands of years preserved a record of early Paleo-Indian culture beneath the sand and mud. Already discoveries of sunken middens or refuse piles and skeletal remains in the waters off Florida challenge our understanding about these earliest inhabitants.

The maze that make up Gray's Reef is certain to hold secrets, yet scientists still know little of the human presence in this region during 8,000-15,000 years ago. Some archaeologists believe that the people



Karen Roeder

Tunicates (cover page) create a current of water through their pharynges to filter and remove plankton. Certain species only centimeters long can pass 173 liters of water through their bodies in 24 hours. Photograph by Matthew R. Gilligan.

Many species of sea basses, including the black sea bass above, are hermaphroditic, that is they begin life as females and eventually become males. The belted sandfish actually functions as both male and female at the same time.

Mariners Weather Log

Gray's Reef is the fourth in a series of articles featuring U. S. National Marine Sanctuaries. One of the more isolated of the sanctuaries, Gray's Reef presents a maze of tall overhanging ledges and passageways in the limestone outcrop for experienced divers. Divers find a rich community of tropical reef fish and invertebrates, soft and hard corals, and sponges on the "live bottom" of the 17-square nautical mile sanctuary.

Special thanks to Reed Bohne, Craig Brown, and Bruce Terrell for their assistance with this article. For additional information, please write:

Gray's Reef National Marine Sanctuary
P.O. Box 13687
Savannah, Georgia 31416

of these times were such effective hunters that they may have been as important a factor in the extinction of animals such as the mammoth and sloth as climactic factors.

"We find evidence of mammoth bones and aggregations of oyster shells that may indicate paleo-indian middens in Gray's Reef," says sanctuary manager Reed Bohne. "It's incredible to think that we may discover important clues of a terrestrial world thousands of years old by exploring the sea bottom 20 miles offshore."

Throughout its history, species have come and gone from Gray's Reef. However, sanctuary staff hopes to change that fate for one of this era's giants, the right whale. Hunted to near extinction in the 1800s and early 1900s, this critically endangered species is attempting an uncertain comeback. Mother right whales migrate to the coastal waters of Georgia from northern waters such as Massachusetts's Stellwagen Bank to give birth. Ironically despite their size, these 50-foot long whales are difficult to see from the surface, and collisions with vessels pose a serious threat to their survival.

"When cows give birth at three to five-year intervals and only to a single calf, how long can the species withstand such losses when only 350 or so remain?" asks Craig Bonn, sanctuary education coordinator.

Aristotle, Pliny, and other ancient naturalists classified sponges like the vase sponge (above) as marine plants. Not until the mid 1700s did scientists discover the animal nature of sponges, albeit the most primitive of multicellular animals. Photograph by Gray's Reef staff.

The clustered hydroids (right) are close relatives to corals, minus the outer skeleton. Photo by Gray's Reef staff.

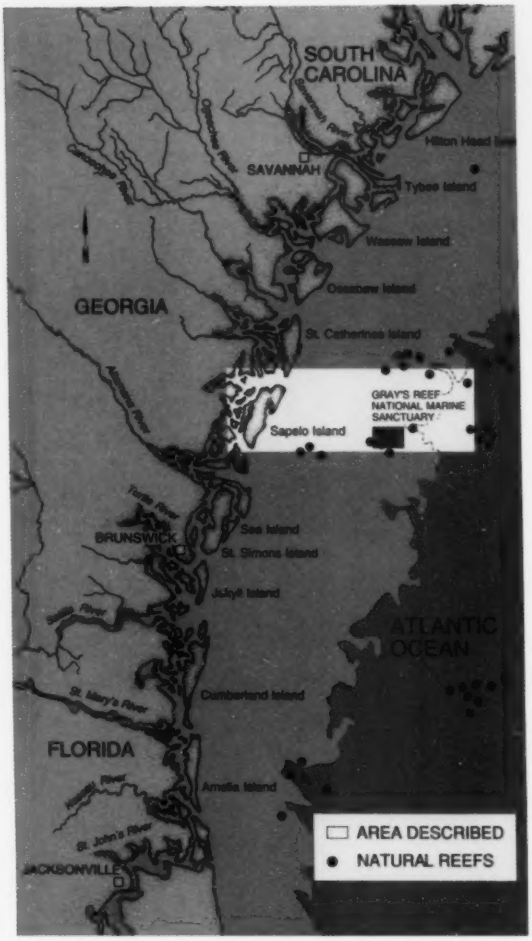
Rivers to Reefs

Rivers to Reefs is a full color NMS poster with artwork and layout by Karen Roeder, University of Georgia Marine Extension Service. It is available for $2 through the University of Georgia, Marine Education Center, P.O. Box 13687, Savannah, GA 31416.

This abbreviated version of *Rivers to Reefs* represents a journey across the major landforms and seascapes of the southeastern U.S. coast. While applicable to most of the barrier islands in the southeast, the poster specifically depicts the area from Sapelo Island National Estuarine Research Reserve in Georgia to Gray's Reef National Marine Sanctuary, 17 miles offshore.

Some of the topographic features of Sapelo Island have been exaggerated and the distance to Gray's Reef has been shortened to portray the ecological relationships among the ecosystems in this area. The coast is a dynamic, constantly changing environment in which ecosystems, extending from rivers to reefs, depend on and support one another.

Artwork and original layout by Karen Roeder



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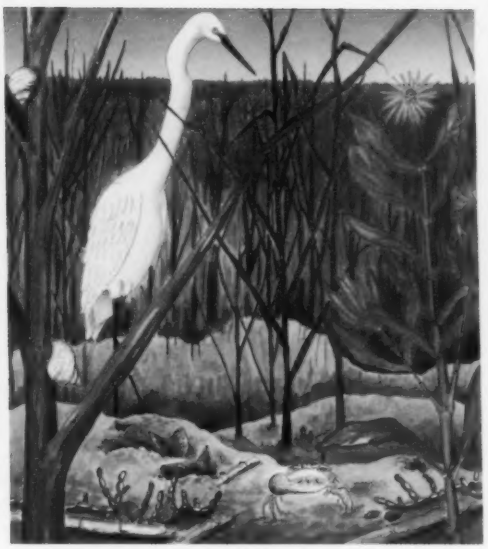

Salt marshes occupy the intertidal zone of our marine coastlines. Although only about 200 miles in length, the marshes of Georgia and South Carolina comprise over one third of the salt marsh acreage of the entire east coast of the U.S. The marshes are one of the most productive ecosystems on the planet, providing structure, habitat, and food for developing fish, shellfish, and the other animals of the coast.

Maritime forests emerge beyond the salt marsh on the upland portion of the barrier island. High humidity, rich soils, and a temperate climate encourage the growth of canopies of oak, magnolia, and cabbage palm above an understory of young trees, palmetto, and shrubs. Unless disturbed by natural or human change, the maritime forest is considered a climax community which will continue to propagate itself and remain relatively unchanged over time.

uffer the maritime forest from the
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Coastal waters that lie beyond the barrier island and extend over the continental shelf contain the greatest abundance and diversity of sea life. Fishing fleets concentrate their efforts in these productive waters. Off the southeast coast in the shallow nearshore zone, fishes such as Spanish mackerel, black sea bass and Atlantic spadefish congregate to feed and, in turn, become prey for larger predators.

Reefs rise from an otherwise barren sandy sea floor. Limestone outcroppings that typify the reefs of the southeast coast provide habitat for communities of invertebrate animals such as sponges and corals. These organisms attract fishes, sea turtles, and other species that use the reef as a source of food and shelter. These natural reefs, known locally as live bottoms, are prized for recreational fishing and diving.

Through public awareness and education, sanctuary staff encourages boaters to be on the lookout for right whales during their November to March visit to the reef and to record and report sightings to local authorities.

Another threatened species that seeks sanctuary in Gray's Reef is the loggerhead turtle. This year-round resident of the Reef is faring better than the right whale. Divers often find female loggerheads resting beneath an overhanging reef, and for good reason. Gray's Reef and similar reefs provide important resting places for female loggerheads during the summer nesting season. Up to seven times a season, female turtles will travel to one of Georgia's barrier islands to lay its eggs on the beach. After returning to the reef, the turtles will rest for up to two weeks while another clutch of eggs matures. Understanding the role of the reef in this important cycle, and educating the users of the reef to avoid interference, helps protect this and other species of turtles.

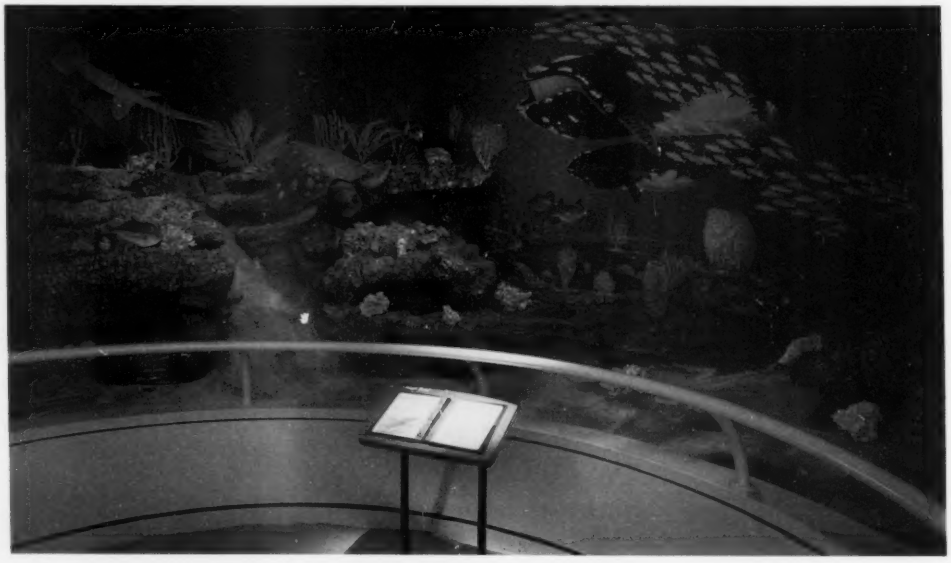
Fortunately, the majority of species living in Gray's Reef still thrive in a stable home of ledges and crevices where both predator and prey hide. For the over 150 species of fish such as Spanish mackerel, black sea bass, Atlantic spadefish found in the reef, daily life centers on either staying out of the food chain or contributing to it. Unfortunately for the prey, evolution seems to have given predators an incredible advantage, and danger looms from all sides and in all shapes. Whereas the hammerhead shark or barracuda is built for speed, the frogfish takes a more sedentary approach. A motionless hungry frogfish will wait quietly, drawing its prey to it with a fleshy lure until it can lunge forward and swallow an unsuspecting fish or crustacean.

Not all prey are easy targets, however. The striped burrfish deters predators by inflating its body with gulps of water, which erects painful spines adding injury to insult. The aptly named convict goby takes no chances. Among the smallest of all vertebrates, this tiny, bar striped fish is only a half-inch long when fully grown. They hover over the sand and dart into their pencil-thin burrows if threatened.

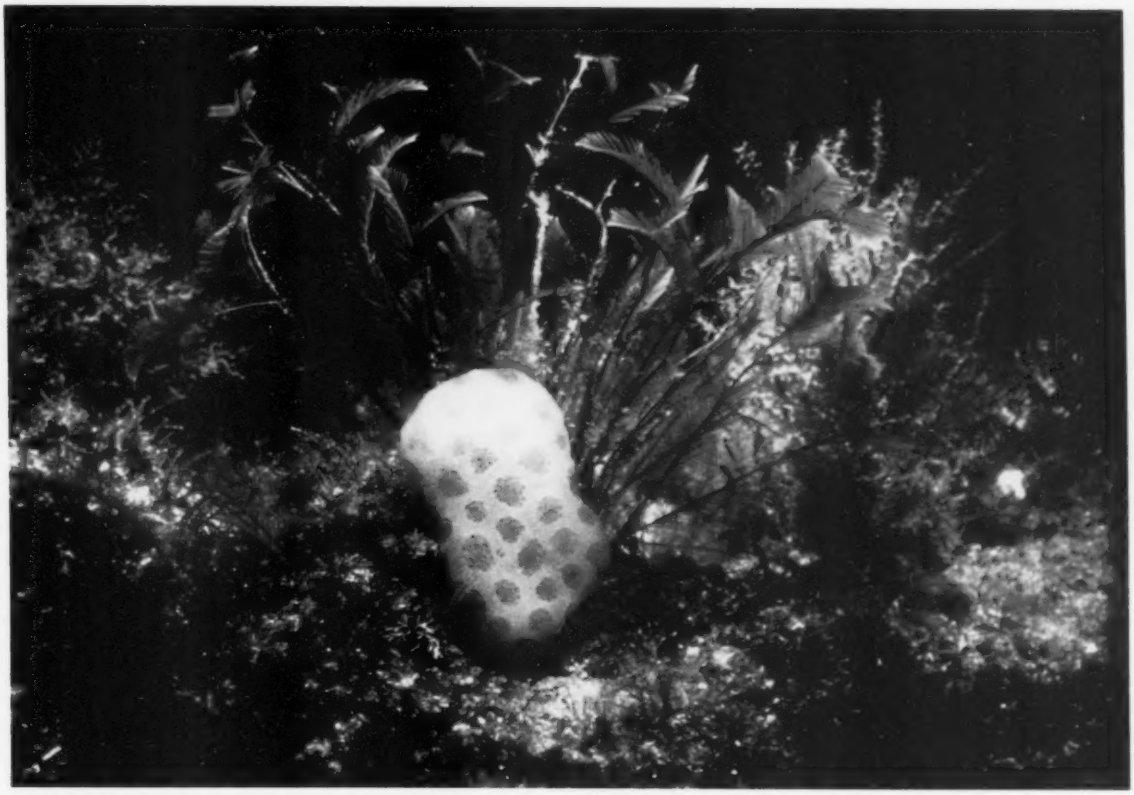
Such a colorful community of neighbors fill Grey's Reef—invertebrates like the sea pork, giant hermit crab, spiny lobsters, acorn barnacle, sea cucumbers, Slate pencil urchin, Michelin's sand dollar, Grey sea stars; banded tulip mollusca; common octopus, fan worms, moray eels, moss-like animals like the bushy bugula; stinging nettles and cannonball jelly; sponges named chicken liver, red finger, or loggerhead.

For predators and prey alike, the lure of a baited hook can sometimes be too tempting. Gray's Reef has been the site of commercial and recreational fishing since colonial times. In the early-19th century, when fisherman called the reef Sapelo Ground, fishing was a local business. The introduction of rail service after the Civil War brought with it new markets in New England for the reef's sea bass, flounder, and red snapper. By the end of the 19th century, Savannah was a major east coast fishery.

Today shrimp fishing is the predominant commercial venture in the nearshore waters off the Georgia Coast. Farther offshore commercial and recreational fishermen go in search of snapper, grouper, and black sea bass. Catches of these species, living in association with live bottom habitat such as Gary's Reef, have dropped 50% along the southeast coast since 1980 due to overfishing. The sanctuary



This Gray's Reef panorama is located at Fernbank Musuem of Natural History in Atlanta, Georgia.

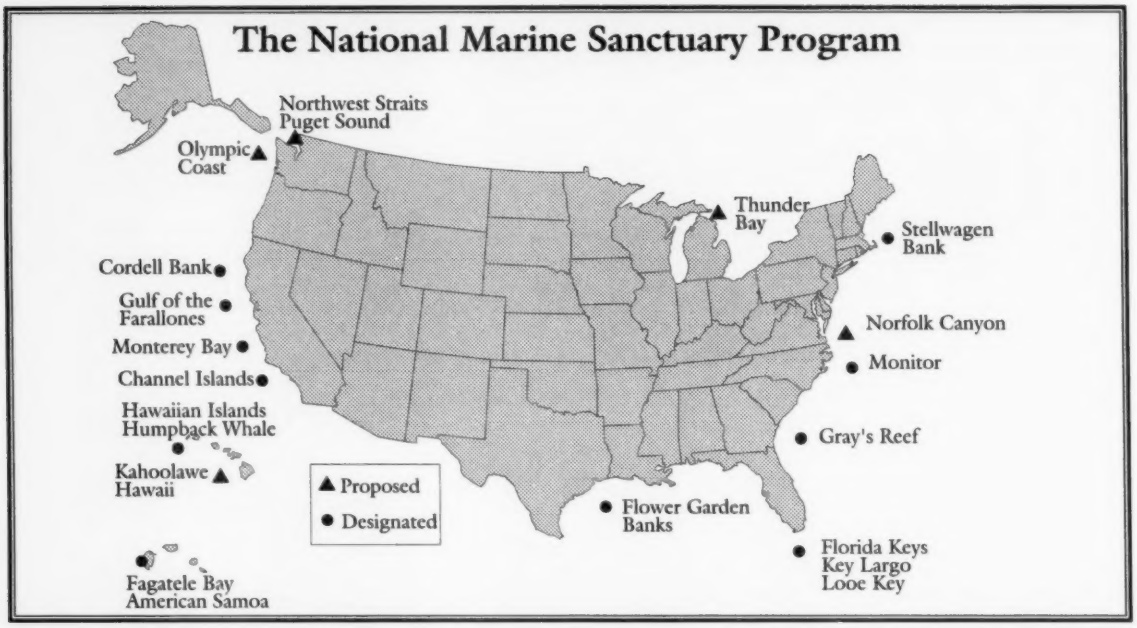


Closely related to the sea anemones, stony corals produce a calcium carbonate skeleton, forming colorful colonies of small polyps. The skeleton provides the substrate on which the polyp can attach, and serves as protection from predators. This photograph was taken by the Georgia Department of Natural Resources.

staff and NOAA's National Marine Fisheries Service have joined forces to conduct reef fish assessments at Gray's Reef. Although sanctuary regulations prohibit certain fishing activities and the use of wire fish traps, these studies allow sanctuary staff to closely monitor the health and long-term productivity of the reef.

President Carter officially designated the Gray's Reef National Marine Sanctuary in January 1981 as a representative live bottom reef. Since then sanctuary staff strives to fulfill the primary objective of resource protection through research and education. One of the principle allies in this effort has been the University of Georgia's Marine Extension Center on Skidaway Island. The center houses sanctuary offices, including a 10,000 gallon aquarium, lecture rooms, laboratories, and interpretive exhibit space. Over the past 6 years, the two groups have jointly developed educational posters, marine curriculum workbooks, and exhibits. An aquarium designed to recreate the Gray's Reef environment gives the thousands of visitors a first-hand impression of the richness of this productive habitat. Most recently, the sanctuary and the center released "Rivers to Reefs," an educational poster depicting the relationship between the estuarine and marine environments and the various coastal ecosystems. The poster shows how important the interdependence of all the coastal ecosystems: river, marshes, maritime forests, dunes, and reef. It illustrates how the estuary near the sanctuary provides "nursery grounds of the seas" as fish, shellfish and other animals are drawn to the nutrient rich "brackish soup," a combination of fresh water and salt water that ebbs and flows with the tide.

That Gray's Reef remains a popular diving and fishing destination, while providing habitat for endangered and abundant species, speaks to the success of sanctuary staff and the state of Georgia in protecting this important resource. However, the job of resource protection is a continuum, necessary to keep this live bottom alive for the archaeologists, biologists, students, fishermen, and divers of tomorrow.



Our nation's marine waters support an incredible diversity of life—the lush kelp forests off the coast of California, the limestone outcroppings of Georgia's Gray's Reef, the tropical coral reef within an ancient submerged volcano of American Samoa, and the colorful coral reefs of the Florida Keys. The mystery and beauty of these delicate ecosystems inspire scientist and poet alike to understand and appreciate their marine treasures. These waters also hold the secrets of our nation's past. Sunken civilizations, naval and commercial vessels, and countless artifacts lie silently waiting for their stories to be told.

In recognition of the special ecological, historical, recreational, and aesthetic values of our marine waters, the National Marine Sanctuary Program was established in 1972 to provide long–term protection and management. Under the direction of the National Oceanic and Atmospheric Administration, 13 marine sanctuaries have been designated, each unique in the natural and cultural resources it contains. Part of the collective riches of our nation, the sanctuaries belong to all of us to enjoy, to learn from, and most important to protect for future generations.

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(301) 713–3141

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The Photographic Doldrums

Michael Halminski

Every now and then I've found myself drifting in, what I call, the photographic doldrums. This is characterized by periods of stagnant creativity and lack of motivation.

Most everyone – athletes, craftspeople, artists, including photographers – experiences slumps in performance. Sometimes it's remedied by the passing of time or just hard work. But I like to approach the problem by starting something new or refreshing. Some change of pace or location is often the answer.

Traveling, particularly aboard ship, brings many unique and interesting photo opportunities. Just leaving the routine of shooting around my home grounds in North Carolina's Outer Banks can renew my enthusiasm.

By far, my most inspirational form of travel for the past several years has come in the form of yacht deliveries. My good friend, Trent Palmer, specializes in running beautiful sailboats, but he is also adept at captaining most types of yachts.

One of may favorite trips was aboard a 70-foot Sparkman and Stevens-designed sloop owned by John McVie of Fleetwood Mac band fame. Back in the 60's, the boat was used for America's Cup contenders to race against for practice, thus the name ***Challenge***. Trent called on me to crew on a journey from Panama to Los Angeles, a trip that is not especially desirable from a sailing standpoint, but I jumped at the opportunity.

Passing through the Panama Canal was an experience of a lifetime, and I shot hundreds of frames. Despite an upwind run for the most part, we hit some smooth sailing off the coast of mainland Mexico. The photo on the following page shows the foredeck of ***Challenge*** as she plunges through the Pacific. I made a number of

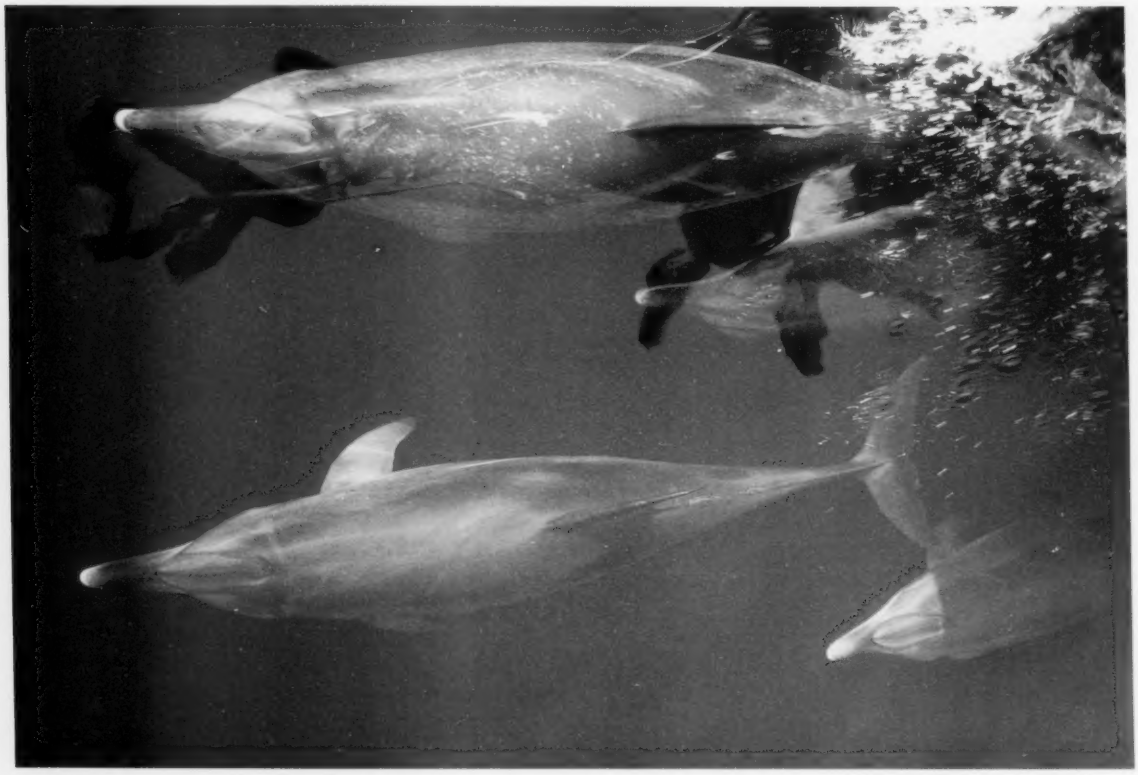
*The **Challenge** breaks Pacific waves on a trip from Panama to Los Angeles.*

exposures with a waterproof Nikonos, holding the camera lens down between shots to keep salt spray from spattering the lens face. I also used the added protection of a lens hood. I did not record exposure data but relied on the automatic mode of the camera. My film was Kodachrome 64.

On another occasion in the following year, I was called again to help bring the Norway registered Swan 53, ***Elysion***, from Connecticut to Fort Lauderdale. This week-long trip produced some varied weather conditions along with some great sailing off the Jersey and Carolina coasts. By the time we were off Georgia, we lost virtually all wind power and resorted to motoring through the glassy water. Eventually, we were joined by a small group of dolphins always a favorite offshore experience.

I've tried repeatedly to photograph them in different conditions with a few lenses and have gotten pictures that I've been moderately pleased with at best. But this time I tried something different. With several dolphins riding in our wake, I decided to use my 20 millimeter wide angle lens mounted on my Nikon F3. Since focusing is much easier with lenses of this range, sharpness was more assured. But looking through the viewfinder, I noticed that it was difficult to shoot my subject without distracting reflections coming off the boat. As I looked down, the dolphins were about 6 feet from me, and I shot repeated exposures anyway. In the final editing of my slides, I found that my best shot actually included the extraneous reflection. I call this shot "The Encounter" and have sold many prints in my gallery on the Outer Banks. One of the similar frames was a cover shot for an issue of *Outer Banks Magazine*, a well-known local publication.

Maybe readers have some photo experiences you'd like to share with us. Send them in to the the *Mariners Weather Log* unless you're stranded somewhere in the photographic doldrums.



This photo was shot on Fujichrome 50 at 1/500th at f5.6. In the upper right is my reflection leaning out over the bow, arms extended holding the camera in front of me. I wasn't even looking through the viewfinder. My two shipmates Dale Parker and Trent also reflected below me, with ***Elysion****'s bow cutting the surface in the lower right corner.*

Radio Schedule Changes

James Nelson
PMO, Houston

HALIFAX, NOVA SCOTIA, CANADA

CALL SIGN	FREQUENCIES	TIMES	EMISSION	POWER
CFH	122.5 kHz	CONTINUOUS	F3C	
	4271 kHz	CONTINUOUS	F3C	
	6496.4 kHz	CONTINUOUS	F3C	
	10536 kHz	CONTINUOUS	F3C	
	13510 kHz	CONTINUOUS	F3C	

TRANS TIME	CONTENTS OF TRANSMISSION	RPM/IOC	VALID TIME	MAP AREA
0001/1201	18HR SIGNIFICANT WEATHER DEPICTION	120/576	12/00	
0015/------	ICE CHART (LABRADOR - IF AVAILABLE)	120/576	LATEST	
------/1301	ICE CHART (GULF OF ST. LAWRENCE)	120/576	LATEST	
------/1401	ICE CHART (NEWFOUNDLAND - IF AVAILABLE)	120/576	LATEST	
0301/------	NMC 3-5 DAY SURFACE PROG	120/576		
------/1501	500MB ANAL	120/576	---/12	
0315/1515	SURFACE ANAL	120/576	00/12	
0401/------	500MB ANAL	120/576	00/---	
------/1601	WAVE ANAL	120/576	1200	
------/1614	12HR SIGNIFICANT WAVE PROG	120/576	0000	
------/1628	850MB ANAL	120/576	1200	
0501/1701	24HR SURFACE PROG	120/576	00/12	
0514/------	WAVE ANAL	120/576	00/12	
------/1714	24HR SIGNIFICANT WAVE PROG	120/576	1200	
0601/1801	18HR SIGNIFICANT WEATHER DEPICTION PROG	120/576	18/06	
0614/------	12HR SIGNIFICANT WAVE PROG	120/576	1200	
------/1814	36HR SIGNIFICANT WAVE PROG	120/576	0000	
0701/------	18HR/24HR 850MB HT/TEMP/WIND PROGS	120/576	18/00	
------/1901	36HR SURFACE PROG	120/576	0000	
0714/------	24HR SIGNIFICANT WAVE PROG	120/576	0000	
0728/------	36HR SURFACE PROG	120/576	1200	
0801/------	36HR SIGNIFICANT WAVE PROG	120/576	1200	
------/2001	18HR/24HR 850MB HT/TEMP/WIND PROGS	120/576	06/12	
0814/------	NFLD SST (WED&SAT) (NS OFA - TUE)	120/576	LATEST	
	NS SST (SUN&THU) (NFLD OFA - MON&FRI)	120/576	LATEST	
------/2014	NS SST (NFLD SST MON, WED, SAT)	120/576	LATEST	
0901/------	SURFACE ANAL	120/576	0600	
------/2101	NS OFA (NFLD OFA MON, WED, SAT)	120/576	LATEST	
------/2120	SURFACE ANAL	120/576	1800	
1001/------	TEST CHART (SUN&WED)	120/576		
	BROADCAST SCHEDULE (MON-THU-SAT)	120/576		
	SATELLITE ORBITAL ELEMENTS (TUE&FRI)	120/576		
------/2201	ICE CHART (NEWFOUNDLAND - IF AVAILABLE)	120/576	LATEST	
1101/------	ICE CHART (LABRADOR - IF AVAILABLE)	120/576	LATEST	
------/2301	ICE CHART (GULF OF ST. LAWRENCE)	120/576	LATEST	

(INFORMATION DATED 05/1993)

Balmer, News, and Awards

Jim Saunders, Baltimore (Balmer) PMO

How did your previous National Weather Service experience help you with your job as PMO?

My previous NWS experience varied widely from Communicator/Teletypist at WSFO Philadelphia, to Weather Service Specialist at WSO Wilmington, DE, with a stop in between at WSFO Pittsburgh. A lot of training and different jobs went into those years. The most significant job that I held which would give me somewhat of an insight into PMO duties was that of supervisory responsibility of a Coast Guard station's observing program. I don't want to get carried away, least anyone think that the change was a piece of cake. Without the assistance of most of the PMOs along the East, Gulf, and West coasts, becoming a PMO would have been quite a task. I must tell you, even today after nearly 3 years, new ideas continue to pop up.

Baltimore was a relatively new port for the VOS program when you took over. Do you think this was a help or hindrance to you?

I think that it helped in some ways because the previous PMO was only in this position a very short period of time. He didn't have time to put a big imprint on the operation of this office. Therefore, it didn't take a lot of changes to run things my way.

Is the port of Baltimore concentrated in the Inner Harbor area or does it cover a much wider area?

Frankly, very little of my ship traffic enters the Inner Harbor. Yes, it is quite spread out. If I were to cover every dock in and around Baltimore, I would have travelled more than 70 miles from my office and back.

Do you cover other areas outside of Baltimore?

I travel to Wilmington, Delaware at least once a week. I also share duties at Philadelphia with Marty Bonk from the Port of Newark, New Jersey.

Do you have much success stressing the value of observations in the Chesapeake Bay? And do you have any ships in the program that only sail the bay?

I have mixed results on local moving vessels. Most of my time is spent chasing bigger fish, so I go after the smaller craft when time permits. But, most of my efforts have been positively received. I do have a couple of research vessels and schooners, but for the most part, I try to steer them to the MAREP program.

Tell us about your family?

My wife and I have two daughters– -a high school senior and a freshman, and a 22-year-old son in training to realize a long time dream of becoming a barber. Of course, I told him that he'd have to go some before I let him come near my head.

Do you have any hobbies outside of work?

I've recently taken up golf, but often I ask myself why!

Above, is a belated 1991 award for the ***Burns Harbor*** *of Bethlehem Steel Corp. They were inadvertently overlooked at the end of the 1991 season. Pictured are the 3rd Mates Ed Gaynor and Charlie Boles with the irrepressible PMO Bob Collins in the middle. The award was accepted on behalf of the Captain and mates. They managed to take 1,000 observations in 1991, the first time it has been done in the Chicago region. Below (left) Chief Officer Hans Wudtke accepts an NWS award for the* ***Sea Merchant****. They also received a SEAS award for this past year. Below (right) holding the award for the m/v* ***Medallion*** *are Captain Alfred Kyhn–Madsen (right) and 2nd Officer George Artieda.*

Heee's back! Jim Nelson, PMO Houston, head tilted to the right and smiling as usual, loves to present awards almost as much as he loves to be photographed. The two well–deserved awards go to the ***Atlanta Bay*** *(left) and* ***Chemical Pioneer*** *(right). Accepting for the Atlanta Bay is Captain* ***George Cooper****. Also present was Captain Larry Nixon of the* ***Columbia Bay*** *who, as Chief Mate, set up the program on the* ***Atlanta Bay****. Nelson made this award on a Saturday– some guys will do anything not to miss a photo op. The award for the M/T* ***Chemical Pioneer*** *(KAFO) for its contribution to the VOS program is accepted by Captain David B. Irvine. The Union Marine Transport Co. vessel carries petrochemical products from the Union Carbide terminal in Texas City, TX to New Jersey. Below (left) Seattle PMO Dave Bakeman (with glasses) presents the USCGC Polar Star with its well–earned award. Accepting are from left to right are MST3 Scott White, MST1 David Hutchinson, and MST3 Jason Rubin. MST1 John Bartholomew is also part of this award–winning crew. Below, right Marty Bonk (PMO, Newark) hands out a 1992 observing plaque to Frank Harty (right) of the Operations Department for Maersk, Inc.*

Los Angeles PMO Bob (Hollywood) Webster made a couple of important presentations above. At top left Captain William F. Mullen receives a VOS plaque on behalf of the M/V ***President Eisenhower****. This is the second time around for the* ***President Eisenhower****. At top right Bob Webster and Captain Christopher MacDonald show off the plaque given to the M/V* ***Polynesia****– its fifth such award. This was enough of an accomplishment that SEAS representative Steve Cook (left) attended the ceremony (who said free drinks?). From the* ***ITB Jacksonville****, (below left), Captain Richard P. Fitzgerald and Chief Mate Logan J. Phillips proudly display the VOS Observing Award for 1992. Below right is part of the crew from the USCGC Polar Sea. Left to right are MST3 R. Duncan Montgomery (who looks like he just got off a mid watch), MST3 Elisa M. Fusco, and MST1 Corey A. Bennett. Unable to attend were MST1 Pete Rose and MST2 Doug Adams.*

*From the **Golden Gate Bridge**, Captain Yatsuka (above) accepts the plaque presented for outstanding weather observing in 1992.*

Henson's Recruits

Charles Henson, PMO Miami had a busy spring. Among his recruits was the Three Harbor Branch Oceanographic Institute in Fort Pierce, FL. Accepting plaques for joining the program (above) are from left to right, Captain Vogel of the R/V ***Edwin Link***, Captain Schwartz of the R/V ***Seaward Johnson*** and Captain van Hoek of the R/V ***Sea Diver***.

The institute located in Fort Pierce, Florida conducts marine research in many areas of marine environmental education and engineering. They done innovative studies in the rapidly expanding field of aquaculture, the responsible farming of the world's oceans, and biomedical marine research, the discovery of pharmaceutical agents from the sea. Beside their own research projects, their submersibles, R/V ***Johnson Sea-Link I*** and ***II***, a Remotely Operated Vichicle, Scoop, and the three research ships conduct research dives for many orginizations including the Office of Naval Research and NOAA.

As we go into print, one of its submersibles is working with NOAA divers and marine archaeologists to recover artifacts and conduct test at the site of the sunken Civil War ironclad ***U.S.S. Monitor***. The 173-foot Union ship lies in 230 feet of water 16 miles off Cape Hatteras, NC where it sank in a gale in 1862. (See the Log's Fall 1992 issue on the Monitor National Marine Sanctuary).

Henson also recruited all 14 ships of the **Tropical Shipping Line**. Below, Henson is welcoming into the program the Director of Marine Services, Mr. Erwin Holder. Tropical Shipping Line is an extremely valuable addition to the VOS program since they cover the important hurricane-spawning Caribbean. Their ships feature both lift on/lift off and roll on/roll off capability and we thank them for volunteering to help support the National Hurricane Center and other NWS functions by taking these tropical observations.

VOS Status and Observing Tips

Martin S. Baron
National Weather Service

The National Weather Service (NWS) Voluntary Observing Ship (VOS) program is organized for the purpose of obtaining meteorological and oceanographic observations from moving ships. It consists of over 1600 vessels and 10,000 observers. Most of the vessels are privately owned commercial cargo ships, such as tankers and container ships. U.S. government vessels operated by the Coast Guard, National Oceanic and Atmospheric Administration, and the Navy also participate.

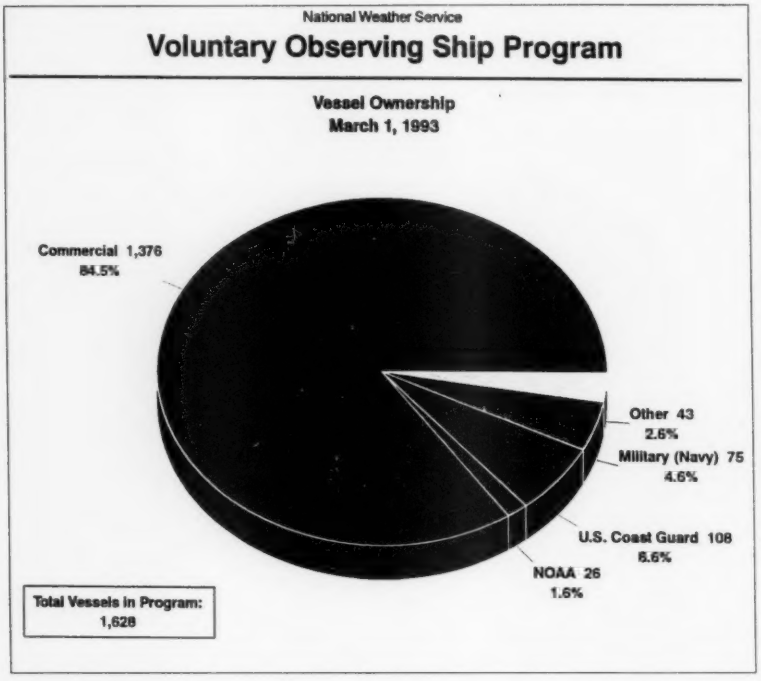
The VOS program operates under World Meteorological Organization (WMO) auspices. There are 52 countries with VOS programs, the U.S. program being the largest. Instrumentation aboard VOS program vessels generally consists of a barometer, barograph, wet and dry bulb psychrometer, and sea water thermometer. Some vessels have anemometers while others estimate wind direction and speed by using the state of the sea and the Beaufort scale.

There are two preferred methods for VOS program vessels to transmit observations--the International Maritime Satellite (INMARSAT) or U.S. Coast Guard stations using Simplex Teletype Over Radio (SITOR), or Morse Code. A third method, using shore commercial relay stations, is also available as a back-up. Also, about 120 vessels use the Shipboard Environmental Data Acquisition System (SEAS), which transmits through geostationary weather satellites. INMARSAT is linked to the NWS through a special weather channel, code 41+, to ensure rapid transmission of reports.

The standard weather reporting schedule for VOS is four times daily, at 0000, 0600, 1200, 1800 UTC. Observations once every three hours (0000, 0300, 0600, etc.) are requested from the Great Lakes, from coastal waters within 200 miles of the United States and Canadian shorelines, and from within 300 miles of named tropical storms and hurricanes. Reports from VOS program ships are transmitted in real-time and are coded using Synoptic Weather Code FM 13-IX Ship.

VOS program vessels report the following elements: wind direction and speed, atmospheric pressure, air and sea-surface temperature, humidity, sea and swell direction, period, and height, present and past weather, cloud type, visibility, ship's course and speed, and sea ice, when appropriate.

Port Meteorological Officers support observing programs aboard Voluntary Observing Ships and are located in 17 United States ports. They are the main point of liaison between the NWS and the shipping community. Much of their time is spent visiting ships and shipping companies, assisting deck officers with observing methods, codes, and report transmission procedures. They also distribute forms, handbooks, and operating instructions, and calibrate some equipment. They recruit new vessels into the program and review observations to ensure quality and com-



pleteness. The names, addresses, and phone numbers of current PMOs are listed in the back of the *Mariners Weather Log*.

Hurricane Season

We are now in the heart of the hurricane season in the Northern Hemisphere (May through November). Observations from moving ships are very important this time of year, especially from tropical waters. They greatly assist in locating tropical storms, determining storm intensity, and forecasting storm development and movement. Please remember to send 3-hourly reports whenever your vessel is within 300 miles of a named tropical storm or hurricane. For your protection, listen to weather forecasts and storm warnings. Be prepared to alter your schedule or route to ensure your safety.

Five Reminders For Weather Observing, Coding, and Reporting

1. **Present/Past Weather**: When reporting present weather (ww) and past weather (W_1W_2), record the form and intensity of meteors in the atmosphere or formed on ship (rime ice and freezing rain form on ship). When no meteors have been present, report any cloud cover or development (code 00–03 for ww; 0–2 for W_1W_2). Meteors are of three types, (1) hydrometeors (aqueous particles such as hail, rain, snow, freezing rain, drizzle, (2) lithometeors (non-aqueous particles such as dust, sand, haze, smoke), and (3) electrometeors (lightning, thunder). The weather data indicator i_x in group i_Ri_xhVV is coded as 1 when significant weather is reported; when there is no significant present or past weather to report, i_x is coded as 2 and the entire weather group $7wwW_1W_2$ is omitted from the weather message.

2. **Wind Direction/Speed**: When using the state of the sea and Beaufort scale to estimate wind speed, remember that rain, as well as surface and tidal currents will damp down the sea waves. Thus, under rainy conditions, or when in the vicinity of a current, your wind speed may actually be a little higher than that indicated from the sea state. Wind direction is always perpendicular to the crest line of sea waves. When using a masthead anemometer, take a mean reading over a 10-minute period and use a wind plotting board to determine true wind direction and speed (not needed if using sea state method).

3. **Sea/Swell**: Don't confuse sea with swell. This is most likely to occur when the local wind direction happens to coincide with the incoming swell. The swell will always have a longer period than the sea, and will be more regular and uniform.

4. **INMARSAT Reports**: Complete the transmission of your INMARSAT weather report in 30 seconds or less. This helps reduce communications costs paid by the NWS. Always end the INMARSAT message with 5 periods to disconnect. If available, please use INMARSAT C rather than INMARSAT A. This also reduces costs, because INMARSAT C has lower connect charges.

5. **Code section 0**: Always include the first 5 code

BBXX	D.....D	YYGGiw	99LaLaLa	QcLoLoLo
Ship report Indicator	Call Sign	Day Hour Wind Indicator	Position Latitiude Indicator	Quadrant Longitude

groups in your weather message. They are a mandatory part of every report. Any omissions or mistakes here can result in the report being thrown out by the computers. All code figures in this section must be filled in as indicated above.

Please review the past five Marine Observations Program columns in this publication or NWS Observing Handbook No. 1 for detailed discussions on these points.

New PMO In New York

We are pleased to announce that Dan Pero is the new PMO in New York City. Dan comes to us from the U.S. Marine Corps, where he completed 13 years of service as a weather observer, a rawindsonde operator/technician, and a weather analyst/forecaster. He also worked on several joint military operations, involving the Marine Corps, the Navy, Army, Air Force and NATO forces in various places around the world. He is married and has four daughters.

Training Cruises Underway

Two NWS employees are helping cadets learn about meteorology and observing methods this summer. Bob Novak, PMO San Francisco, is aboard the ***Golden Bear***, training ship of the California Maritime Academy. Carl Bowser, Radar program focal point at NWS headquarters, is aboard the ***Texas Clipper***, training ship of the Texas A/M University at Galveston Merchant Marine Cadet Corps.

New Recruits: April – June, 1993

During the 3-month period ending June 30, 1993, PMOs recruited 71 vessels as weather observers/reporters in the NWS VOS Program. Thank you for joining the VOS program. Observations from moving ships form the basis of marine data acquisition programs worldwide. Data shortages still persist from some areas and at certain reporting times. From the North Atlantic and North Pacific oceans, more observations are needed at 0600 and 1200 UTC. These are your late night/early morning reports– please make every effort to transmit them. More data is also needed from coastal waters, especially off the U.S. and Canadian west coasts, and from the Carribean Sea. During the Northern Hemisphere hurricane season (May – November), reports from the tropics and the easterly trade wind belt (roughly 5°, 35°N) are especially important. Data from the Southern Hemisphere (the South Atlantic, Indian, and South Pacific oceans), is in particularly short supply. There is also a shortage of data from the Arctic ocean.

Some misinformation still persists about the importance of reports close to the coast. These reports are extremely valuable, not only for the marine forecaster, but also for weather forecasts prepared for land areas near shore. Weather in the coastal zone can be very changeable and often moves inland. The forecaster needs all the information he can get. There is a 3-hourly reporting schedule in all United States and Canadian Coastal waters out 200 miles. Please comply with this schedule, time permitting.

When taking and recording observations, accuracy is of paramount importance. An inaccurate observation can mislead the forecaster and result in a poor forecast. A reliable observation can hold the key to a complex meteorological situation. Accuracy is also important for research purposes. For example, the World Climate Research program requires very precise temperature data (air and sea-surface), accurate to the nearest $^{1}/_{10}$° centigrade.

NATIONAL WEATHER SERVICE VOLUNTARY OBSERVING SHIP PROGRAM
NEW RECRUITS FROM JAN.1, 1993 TO MAR 31, 1993

NAME OF SHIP	CALL	AGENT NAME	RECRUITING PMO
ADVENTURER	WBM3015	CROWLEY MARITIME CORP	MIAMI, FL
AMERICAN MERLION	KUS9887	OSPREY SHIP MANAGEMENT, INC	SEATTLE, WA
AMULET	OYVW6	BRANDTSHIP USA, INC	JACKSONVILLE, FL
BETTY GALE	WR7615	GENERAL MARINE TOWING	CHICAGO, IL
BROOKLYN BRIDGE	EEZJ9	K-LINE AMERICA INC	SAN FRANCISCO, CA
BULWARK	WBM4113	CROWLEY MARITIME CORP	MIAMI, FL
CAPE HORN	KMJS	CAPE HORN, INTEROCEAN MANAGEMENT CORP.	NORFOLK, VA
CHIQUITA ITALIA	C6KD5	GREAT WHITE FLEET - CHIQUITA CENTER	BALTIMORE, MD
CHIQUITA JEAN	C6LK7	GREAT WHITE FLEET, LTD.	JACKSONVILLE, FL
CROWN PRINCESS	ELGH5	ELLER AND COMPANY//C/O GEORGE PARRA	MIAMI, FL
DEAN FOSS	WY3090	FOSS MARITIME CO	SEATTLE, WA
DEL MONTE CONSUMER	ELIU4	DEL MONTE TROPICAL FRUIT CO.	NEWARK, NJ
DEL MONTE TRADER	ELIU3	DEL MONTE TROPICAL FRUIT INTL	NEWARK, NJ
DELMONTE TRANSPORTER	ELIU2	DEL MONTE TROPICAL FRUIT CO	MIAMI, FL
ELSBORG	OWOS2	WECO AGENCIES (TEXAS), INC.	HOUSTON, TX
FOREST HAWK	ELIQ7	NORDIC ORIENTAL SHIP MGT PTE LTD	NEWARK, NJ
GLOBAL MARINER	KUS9897	TRANSOCEANIC CABLE SHIP CO.	BALTIMORE, MD
GRANDIS	3EQV8	WILLIAMS, DIMOND & CO.	SEATTLE, WA
GRIMSNIS	V2BN	GLOBE SHIP MANAGEMENT, INC	MIAMI, FL
HAWAII RESPONDER	KUS9831	CAPT. HARRY PHILLIPS LLL	NEW ORLEANS, LA
HERCULES BULKER	5MRQ	SUNRISE SHIPPING AGENCY INC.	SEATTLE, WA
INDIAN GOODWILL	ATRU	INDIA STEAMSHIP CO.LTD	NEW ORLEANS, LA
JEAN LYKES	WLAH	LYKES BROTHERS SS CO	NEW ORLEANS, LA
JEZERA DELMAS	J8FI2	BIEHL & COMPANY	HOUSTON, TX
KAHO	WZ2043	U.S. FISH AND WILD LIFE	CHICAGO, IL
LADY MARYLAND	WTU4008	LIVING CLASSROOM FOUNDATION	BALTIMORE, MD
LAKE	WMDY	AMERICAN OVERSEAS MARINE CORP.	SAN FRANCISCO, CA
LIBERTY VICTORY	DVHE	MYERS GROUP (US)	SEATTLE, WA
LOA	ELOF7	SOUTHERN SHIPMANAGEMENT	LOS ANGELES, CA
LONGAVI	ELOF6	SOUTHERN SHIPMANAGEMENT	LOS ANGELES, CA
LONTUE	ELOJ2	ROBERT C. HERD & CO., INC.	BALTIMORE, MD
MAERSK BOGOTA	V2MC	UNIVERSAL MARITIME	MIAMI, FL
NEW YORK SUN	WSKD	SOUTHERN STEAMSHIP//C/O KEVIN CHIPLOCK	MIAMI, FL
NOSAC ROVER	LAKA4	NORWEGIAN AMERICA LINE	JACKSONVILLE, FL
OCEAN EMPRESS	ELJU4	GENERAL STEAMSHIP CORP.	SEATTLE, WA
PC EXPLORER	3EYE9	NYK LINE (NORTH AMERICA INC.)	SEATTLE, WA
PEGGY ANN	WAW5723	GENERAL MARINE TOWING	CHICAGO, IL
PETER W. ANDERSON	WXQ7334	MAR INC-MARINE DIVISION	NORFOLK, VA
SANTA MERCEDES II	3ELQ2	TERMINAL SHIPPING CO., INC	MIAMI, FL
SEA COMMERCE	ELGH7	INCHCAPE SHIPPING	MIAMI, FL
SEA RACER	WX6371	CROWLEY MARITIME CORP	MIAMI, FL
SEA VALOR	WBN9212	CROWLEY MARITIME CORP.	SEATTLE, WA
SEABOARD GIANT	OXGC2	SEABOARD MARINE LTD.	MIAMI, FL
SEABOARD HORIZON	9VKK	SEABOARD MARINE LIMITED/C/O BILL BYLUND	MIAMI, FL
SEABOARD OCEAN	OYMO2	SEABOARD MARINE LIMITED//C/O BILL BYLUND	MIAMI, FL
SKAUKAR	ELFZ8	S & C MARINE A. S.	JACKSONVILLE, FL
STAR DROTTANGER	ZCKU	STAR SHIPPING INC	SEATTLE, WA
STENA TRANSFER	ZCAF8	CROWLEY AMERICAN TRANSPORT, INC	MIAMI, FL
STRONG AMERICAN	WTF5189	BENGTSSON WALKER MARINE	JACKSONVILLE, FL
SUPERTEN	C6IH4	MORTON AND COMPANY	MIAMI, FL
TARGA	C6IZ6	CONTAINER SHIPPING	MIAMI, FL
TARPON SANTIAGO	C4OA	TARPONSHIP S.A.M.	NEW ORLEANS, LA
TRICORD SUCCESS	DUEH	WILLIAMS, DIMOND & CO.	SEATTLE, WA
TRIGGER	ELDU4	SOUTH ATLANTIC ENTERPRISES INC	SEATTLE, WA
TROPICAL BEAUTY	HQFT6	NATIONAL WEATHER SERVICE, PMO	SEATTLE, WA
TUZLA	P3DH4	KERR STEAMSHIP CO, INC.	MIAMI, FL
USCGC BLUEBELL	NODD	COMMANDING OFFICIER	SEATTLE, WA
USNS CAPABLE	NKSZ	MILITARY SEALIFT COMMAND	NORFOLK, VA
USNS CATAWBA T-ATF 168	NCDS	COMMANDING OFFICER	SEATTLE, WA
USNS COMFORT	NCOM	MILITARY SEALIFT COMMAND (USA)	BALTIMORE, MD
USNS MERCY	NMER	MASTER	SAN FRANCISCO, CA
USNS TIPPECANOE (TAO-199)	NTIP	COMMANDING OFFICER	NEW ORLEANS, LA
WILLIAM A. WHITNEY	WAZ8787	GENERAL MARINE TOWING	CHICAGO, IL
YOUNG SATO	3EFH4	TAIYO SANGYO TRADING & MARINE SERVICE LTD	SEATTLE, WA

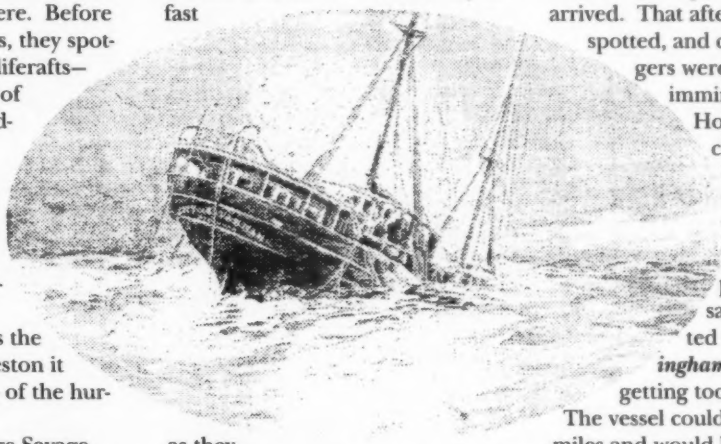
The *City of Savannah* Hurricane—100 years ago

In August of 1893 a devastating hurricane swept through Georgia and South Carolina generating a 17- to 20-foot storm surge that ravaged the offshore islands, leaving more than 2,000 people dead. On Tybee Island almost every building was destroyed. In one of the most dramatic encounters of the storm, the steamship ***City of Savannah*** was caught hours before making its destination.

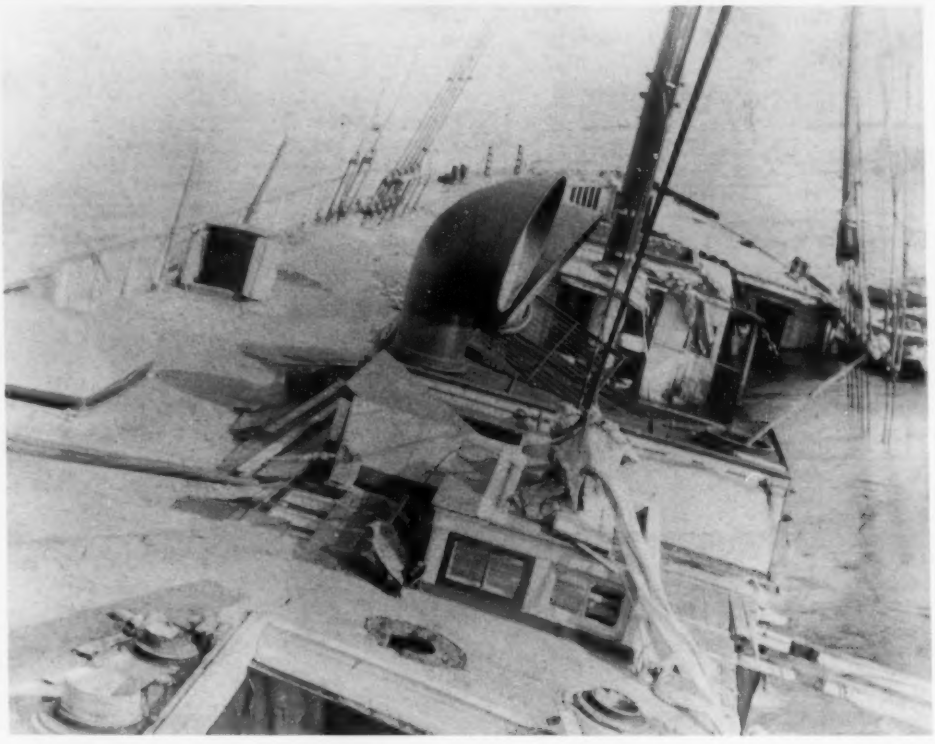
Built in 1877, the 272-foot ***City of Savannah*** left Boston on the 24th with a crew of 47 and 20 passengers, and headed for Savannah, Georgia. Right from the start the weather was rough, and conditions went downhill from there. Before reaching Cape Hatteras, they spotted a couple of empty liferafts—an ominous harbinger of things to come. Rounding the Cape on the 26th, they ran into a heavy southeast sea. The wind began to blow from the northeast, and by the following day it reached hurricane strength. As the steamer neared Charleston it fell within the full grip of the hurricane.

Captain George Savage ordered the ship to hove to. It was hit by a particularly heavy sea, which swept clean over the vessel taking the pilot house with it. Captain Savage, who was in the pilot house at the time was driven through the wall and carried through his cabin and into an adjacent smoking room. Although he was dazed by this blow, he soon regained his senses.

Winds and waves continued to strengthen, and on the evening of the 27th, the vessel shipped a sea which carried the smokestack overboard. The engineer plugged the hole to try and preserve the fires and some steam. This was partially successful, but water continued to flood the vessel. Crew and passengers bailed in an attempt to keep the water at bay. Captain Savage ordered all sail set, but the wind blew the sails away as fast as they could be hoisted. Soon the vessel was at the mercy of wind and sea. By now the captain realized that there was nothing left to do but let the vessel drift ashore. The ***City of Savannah*** was about 15 miles from shore when it lost its smokestack, but drifted all night before being driven aground. Early Monday morning the 28th, the vessel struck bottom northeast of St. Helena Is. They were in 6 fathoms of water, but the anchors could not hold in the turmoil. Captain Savage decided to flood the ship even further to provide some stability. Waves continued to pound the vessel, which began to come apart. A boat was sent out to search for assistance. By Tuesday morning with no word, Captain Savage decided to send the women and children ashore in two lifeboats for fear that the vessel would break up before help arrived. That afternoon a tug was spotted, and crew and passengers were heartened by the imminent rescue. However, after circling for several hours the tug gave up and left. Spirits were at a low ebb at this point. Later that same day they spotted the ***City of Birmingham***, but it was getting too dark to help. The vessel could only get within 4 miles and would have to send boats the following morning.



The ***City of Birmingham***, under the hand of Captain Berg had itself been through a rough voyage in the hurricane. They had



*The wreck of the **City of Savannah** in 1893 (right). At Hilton Head Lighthouse, Lightkeeper Paul Schwarzer wrote: "On the 27th a hurrican (sic) visited this station, wrecking the Front Light Station, the sidewater came within 300 yards of the Rear Light. Front Beacons' foundation was undermined by the sea wich (sic) caused the Beacon to lean over to the N. East. Storehouse was left off its piers and floated up 150 yards toward Rear Beacon. Kitchen blowed down entirely and the piers and cistern under dwelling badly wrecked, making it dangerous to live in."*

already rescued the Captain and 6-man crew from the schooner ***Joseph Soutter***. One of the passengers aboard the ***Birmingham*** describes the scene after they rounded Cape Hatteras: "As far as the eye could reach could be seen the enormous seas which seem to lash each other in their madness while the wind howled and with what seemed to be a terrible voice urged on the giant mountains of water to do their worst. From 7 to 12 o'clock it was a scene fearful to behold such a one as to make strong men fear, and the ship, which had long since been headed for deeper water, seemed to be but a mite in the hands of the elements to be dashed about at their mercy; but a strong and steady hand, cool and determined, was at the helm; the captain was there to guide and protect the ship and the living that were in his keeping."

That night the crew and remaining passengers on the ***Savannah*** once again lashed themselves to the rigging. Two boats were sent from the ***City of Birmingham*** at daybreak, and by noon, 41 tired and hungry crew and passengers were safely aboard the vessel.

Meanwhile, Captain Peter Finney of the steamer ***Bessie***, who after leaving Savannah for Beaufort had ridden out the storm on St. Helena, returned to Savannah on the 30th with the news of the wreck. As the ***City of Birmingham*** made its way into Savannah with the ***City of Savannah*** flag draped over its side, more than 1,000 people flooded the wharf to get news of the survivors. As soon as they returned to Savannah, Captain Savage set out with the tug ***Paulsen*** to find the others. They arrived at St. Helena where they found one party safe and well cared for at the home of Senator Don Cameron. The others were found on Hunting Island some 7 miles from St. Helena. They were also being well cared for by lighthousekeeper F. W. Kanehl and his wife. Through all this suffering and severe weather, not a single soul was lost.

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*This account was taken from several local newspapers of the day. The photograph and the sketch from the February 1894 **Scribners Magazine**, by Daniel Smith came from the Beaufort County Library with valuable assistance from Hillary Barnwell. Hillary also provided the account of the Hilton Head Lightkeeper, who was a relative of her husband's.*

*For a complete account of this storm see **Weatherwise**— August– September, 1993.*

North Atlantic Weather January, February, and March 1993

January—An abnormal Azores–Bermuda High featuring a 1028 mb center over the Iberian Peninsula and extending westward across the Atlantic forced the winter storms northeastward into the Norwegian Sea and through the Denmark St.

As the month opened a 964–mb Low just south of the Kap Farvel was generating gales. The DXYL (61°N, 33°W) measured 35–kn winds in 13–ft. seas. However, this was a short–lived system and was followed by a potent Low from the Gulf of St. Lawrence. On the 3rd, this storm crossed the 55th parallel with a 956–mb pressure and absorbed another system. By 1200 it was dominating the weather from the Bay of Biscay to the Denmark St and northward over the Norwegian and Greenland Seas. Storm force winds were received from vessels such as ***Norna***, ***TFXP***, ***D54A***, ***Cumulus***, and the ***GBXW***. Seas were running 15 to 25 ft. At 1500 on the 3rd, the ***Cumulus*** reported a 962–mb pressure in 23–ft. swells near 57°N, 20°W. Along the southern Norwegian coast platforms were measuring 50–to 55–kn winds and at 0000 on the 4th, the ***LF3J*** (61°N, 2°E) was belted by 58–kn southerlies. By this time the 950–mb Low had crossed Iceland and was moving through the Greenland Sea. It began to weaken on the 5th. However it was replaced by a more potent system 2 days later.

It began innocently enough on the 4th as a Low over Illinois. By the 7th it was a 976–mb Low near 58°N, 26°W and part of a multi–centered system with a 966–mb center in the Denmark St and a weaker center over Iceland. However, before the 7th was over its pressure dipped to 956–mb. Winds south of the center were already storm force and the British Isles were taking a beating. By 0000 on the 8th, its 942–mb center had crossed the 65th parallel near 5°W. At 0600 on the 8th, the ***Polarfront*** (66°N, 2°E) battled 49–ft seas in a 59–kn southwesterly and measured a 955–mb pressure. This vessel reported similar conditions for the next several hours and estimated seas at 53–ft at 1200. Several other reports of 40–ft swells verified these horrible conditions in the Norwegian Sea. At another time this wicked system would have earned Monster of the Month title, however, it was replaced by an even greater monster.

Monster of the Month— On the 6th a stationary front stretched from the Gulf of Mexico northeastward into the northern North Atlantic. Several atmospheric waves had formed along this front and one, east of Florida, was soon to become a monster. For several days it was barely noticeable as it drifted slowly northeastward. By the 9th, it gained a recognizable circulation and then exploded. At 0000 on the 10th, its 960–mb center was located near 55°N, 22°W. However, there were two 958–mb centers to the north so it was no big deal. The ***Cumulus*** (57°N, 18°W) measured a 972–mb pressure in 45–kn southerlies. Then the bottom dropped out. At 0000 on the 11th as the storm moved across the Faeroe Is, it was analyzed at 916 mb. That is not a misprint—916 mb.— Hurricane Andrew's lowest pressure was 922 mb.

Storm force winds were common beginning on the 10th. At 1800 the ***Showa Maru*** (59°N, 10°W) measured a 57–kn southwest wind, a 946.5–mb pressure and 21–ft swells. During the first 12 hr is on the 11th, more than two dozen radio reports came in with pressures of 960 mb or less; seven of these vessels measured pressure below 950 mb. In general winds were in the 50– to 65–kn range. Sea and swell were running 10 to 25 ft. At 1200 on the 10th, the ***Cumu–***

lus within about 150 mi of the 919-mb center reported 33-ft seas and 55-kn winds. The ***Lagarfoss*** a little north of center was raked by 68-kn northeasterlies. Both vessels were sailing in snow at the time. At 1800 the ***LFAW*** (61°N, 3°E) ran into 60-kn southerlies in 25-ft swells. The ***Frithjof*** (62°N, 7°W) at 0600 on the 11th measured 68-kn winds in snow showers. A platform 62130 (53°N, 3°E) measured a 78-kn northerly at 1200 on the 11th.

This vicious storm held its power through the 12th when its pressure rose to 939 mb, and it headed along the 65th parallel toward Norway. At 0300 on the 12th, the ***LBHA*** (73°N, 18°E) in the Barents Sea was rocked by 26-ft swells in 66-kn northeasterlies. A breather finally came on the 13th for the turbulent waters of the Barents, Greenland, North and Norwegian Seas as well as the northeastern North Atlantic.

However, it was a brief respite as a 955-mb Low moved into the waters between Iceland the Faeroe Is on the 15th. South and east of its center, ships were battling 35- to 50-kn winds.

During the second half of the month, two more intense storms passed between the Faeroe Is and Iceland. On the 21st a 952-mb system moved directly over the Faeroe Island and then eastward into Norway. It brought 40- to 55-kn winds and waves were estimated at 15 to 30 ft. This system had plagued shipping from the 18th when it moved across the Grand Banks as a 962-mb storm. After the 22nd, it began to look like this hectic month would end on a quiet note, but it was not to be. On the 26th, a Low formed off the Outer Banks of North Carolina. It deepened on the 28th as it crossed Newfoundland. Then the pressure really plummeted. From 974 mb at 1200 on the 28th, it fell to 956 mb in 24 hrs as its center moved into the Denmark St. This wasn't the end of it either. By 1200 on the 30th, its 944-mb center was making a beeline toward Spitsbergen in the Greenland Sea.

Casualties– On the 5th at about 0500, the tanker ***Braer*** carrying 84,000 tons of oil from Norway to Quebec broke down 10 mi south of Sumburgh Head, the southernmost point of the Shetland Is. The crew abandoned the vessel via helicopter, and it drifted aground at Garths Ness, northwest of Sumburgh Head. The extremely rough weather that occurred during the next week resulted in the breaking up of the tanker and one of the worst oil spills in European history.

The cement carrier ***Coty I,*** Piraeus for Italy, sank in heavy seas off Cape Maleas on the 6th after the crew of 17th abandoned the vessel. All 17 were missing and search and rescue operations were hindered by force 10 winds. Four bodies were found.

The ro-ro ferry ***Jas Heweliusz*** capsized in violent weather some 20 mi off the German Island of Rugen in the Baltic Sea. Some of the 32 passengers jumped into the 2°-C water. At the time of the capsizing, it was estimated that winds were blowing at about 90-kn with seas of about 10 ft. Survivors said that the ship listed so quickly that there was very little time to launch lifeboats. There was a crew of 29 with 35 passengers aboard the vessel. At last report 39 bodies were recovered with 17 people still missing. There were nine survivors.

On the 17th, the ro-ro ferry ***Stena Hibernia*** was hit by a freak wave in the Irish Sea. The vessel, carrying 278 passengers, 67 crew members and 33 cars, was rolled off course by one wave and then hit by a second wave which resulted in injuries to 20 people. According to reports, the incident was attributed to a freak wave pattern rather than the strength of the gales.

Also on the 17th at about1930, the fish factory vessel ***Steponas Darious,*** developed engine problems in force 10 winds with heavy swell. Suddenly while being towed, a heavy sea smashed the wheelhouse and knocked out all navigational aids and steering control 2 mi south of Sumburgh in the Shetlands. Steering was later regained and the vessel returned to Lerwick. The cargo vessel ***Frigo*** grounded in heavy weather north of Trondheim, Norway on the 17th. The crew was rescued, but the vessel subsequently sank.

On the 27th, the ro-ro which had been disabled and adrift off the North Carolina coast was anchored and secured in stormy seas after four crew members were dropped on board the unmanned vessel by helicopter. The original crew had been evacuated after a towline snapped and efforts to attach a new line failed. The ***Lyra*** was carrying 340,000 gallons of engine fuel and 40,000 gallons of diesel fuel.

February– Similar to January, a large 1030-mb Azores-Bermuda High dominated the North Atlantic. This enormous departure from normal resulted in positive anomalies of up to 18 mb. A normal climatic chart for February shows the North Atlantic dominated by the Icelandic Low with only a hint of the Azores High off Africa. Where was the Icelandic Low? Squeezed into two small centers on either side of Greenland. Where was the action? Mainly from the Grand Banks to the Denmark St with some secondary activity in the Labrador Sea.

The first week of the month was a mariner's nightmare from the Grand Banks through the Denmark St. On the 1st a 956-mb Low was analyzed with its center between Kap Farvel and Iceland. At 0000 the ***Bjarni Saemundsson*** reported 52-kn winds and a 977-mb pressure near 65°N, 24°W. The gradient between this storm and a massive 1044-mb High over Europe was so tight that southwesterly gales and storm force winds were being generated from just west of England to the northern coast of Norway. There was also a long fetch for waves to build. For example, at 1200 on the 1st the ***Deepsea Bergen*** (67°N, 11°E) measured 62-kn westerlies in 35-ft swells. By the 2nd this system was in the Greenland Sea but was replaced by a 962-mb Low. The two of them along with the 1043-mb High kept conditions miserable over the entire northeastern North Atlantic region. In general winds were blowing in the 40- to 60-kn range with seas of 15 to 25 ft. There was some relief on the 4th although a 962-mb Low moved into the region early on the 5th. This system had developed east of New Jersey on the 2nd but really began to deepen on the 4th. Fortunately, it was short-lived but the ***TFTV*** (63°N, 23°W) ran into 52-kn easterly at 1200 on the 5th and several reports of gales were received south of the storm center which was accelerating through the Denmark St. The North Atlantic remained relatively quiet until a powerful Low from the Gulf of St. Lawrence blossomed south of Kap Farvel on the 10th. Its pressure plummeted from an estimated 994 mb at 1200 on the 9th to 956 mb some 24 hrs later. Fortunately, the pressure gradient wasn't too severe so that winds were generally running between 40 and 50 kn. Seas were in the 15- to 20-ft range. As the system approached the Denmark St, it slowed and nearly stalled. Ships in the area continued to report gale force winds into the 12th with a few storm force reports (50 kn or more) particularly east of the center.

The second half of the month was a piece of cake compared to the first half. Several storms moved through the Denmark St and intensified into the 960-mb range on the 23rd and 24th but were far enough north not to create major weather problems. Several storms moved through the Gulf of St. Lawrence and into the Labrador Sea and did generate minimal gale force winds in these waters, but for the most several large Highs controlled the weather across the mid North Atlantic.

Casualties– The Mv ***Kapten Konga***, Tallinn for Aarhus on the 1st, collided in dense fog with the Mv ***Ringes*** 1 mi north of Drogden Light. ***Ringes*** was badly holed on its port side. On the 3rd severe weather along the Norwegian coast caused a shipwreck in the North Sea and halved oil production in Norway. Storms raged across the area for several days. A Norwegian Rescue Service helicopter was barely able to take off in order to save the crew of the mv ***Rhino*** which was being pounded by huge waves. The entire crew of eight was plucked off the ***Rhino*** which ran aground 25 mi south of Bodo. Waves were reported at 20 ft. The Mv ***Minerva*** west of Norway for Tofte with a cargo of timber lost part of its deck cargo off Sogneoksen during heavy weather on the 3rd. On the 16th a Haitian ferry, the ***Neptune***, sank in a strong squall 60 mi west of Port au Prince. At last report 175 bodies were recovered, and there were 285 survivors out of the estimated 1,000 to 2,000 on board.

The empty tanker ***Freja Svea*** broke its moorings and was driven aground on the rocks off the northeast coast of England toward the end of the month. Helicopters rescued 9 crew members while 12 remained on board. Rescue efforts by boat and efforts to refloat the tanker were hampered for several days by 30-ft seas and 50-kn winds. On the 28th the container vessel ***Zim Antwerpen*** struck the Vorontsovskiy Lighthouse (Odessa) in dense fog putting it out of action.

March–The Azores-Bermuda High May with a large 1022-mb center spread its circulation from the U.S. to Europe and Africa in conjunction with a secondary 1022-mb High over Europe. However, the Icelandic Low was also intense with a 992-mb center in the Denmark St. This combination of climatic pressure features means trouble along the shipping lanes, particularly the northern ones.

During the first half of the month several 970-mb storms moved from Kap Farvel through the Denmark St. In fact, the month opened with a 978-mb center in the Denmark St whose circulation was intensified by a large 1036-mb High covering the Mid North Atlantic and a huge 984-mb Low covering the Mediterranean. As a result, storm force winds were being reported in several areas. The ***Irving Nordic*** measured 50-kn winds as did the ***Stonewall Jackson*** which was battling 23-ft swells. The ***Galveston Bay*** (38, 49°) checked in with 52-kn south southwesterlies in 33-ft swells while the ***Northern Enterprise*** (38°N, 55°W) was racked by 58-kn westerlies in

41-ft swells. Also the ***Canmar Ambassador (48°N, 32°W)*** reported 40-kn southerlies in 23-ft swells. Pressure gradients slackened somewhat on the 3rd as the northern Low moved northeastward and weakened while the Mediterranean Low began to fill. The High remained intense.

Monster of the Month– For preliminary details on this storm see the Spring 1993 issue of the *Mariners Weather Log* (Vol. 37, No. 2) on page 38. In that summary, the details on the core samples for the snow/water ratio have been found to be in error. While it was a heavy snow, it was not quite that heavy. This summary is still preliminary and is based upon Northern Hemisphere Surface Charts supplemented by ship reports.

During the week preceding the monster, it was apparent that upper atmospheric conditions were aligning themselves and the potential was going to be there for a storm of unprecedented magnitude. Forecasters were issuing warnings about this system well before it ever developed, which was important for marine operations in the Gulf of Mexico and along the East Coast of the U.S.

On Friday, March 12th, a 1000-mb Low was analyzed northeast of Brownsville, TX. By 0000 on the 13th, its central pressure was estimated at 989 mb. At 2100 the ***Columbia Bay*** reported a 990-mb pressure northwest of the center. They indicated that seas built from 3 to 4 ft to 10 to 12 ft in 1 hr and then to 18-20 ft in the next hour while winds were gusting to 70 kn. The ***Inger*** at 0300 on the 13th was more than 100 mi to the south when it recorded a 991-mb pressure. By the time the storm passed over southern Georgia, its central pressure had dipped to 972 mb.

The storm generated gusts to 98 mph on South Timbalier and 92 mph on south Marsh Is, both in Louisiana. Hurricane force wind gusts were reported all along the East Coast and as the storm moved northward it pulled cold air deep into the South– Orlando measured a 32°-F temperature in its wake. Blizzard conditions were reported from Alabama to Maine while more than 25 tornadoes ravaged parts of Florida. At 1800 on the 14th, the ***Jo Elm*** ran into 64-kn westerlies. By this time the 963-mb center was in the Gulf of Maine. The ***Global Link*** which was docked in Baltimore had recorded pressure of about 956 mb at around 2000 on the 13th (see pg. 45, Spring 1993 issue). This was nearly matched by a 958.4-mb reading at White Plains, NY. The ***Tropic Sun*** encountered seas that were at least 60 ft high off Cape Hatteras on the 13th.

By the 15th the Low began to weaken as it moved off Newfoundland. Central pressure rose to 970 mb by 1200. It reintensified briefly and reached Iceland sporting a 964-mb center at 1200 on the 16th, generating gales between Iceland and England.

A couple of moderate Lows popped up dong the second half of the month but paled in comparison to the big monster. One worthy of note formed on the 18th just off Kap Farvel. As it moved into the Denmark St it intensified rapidly. By 0000 on the 20th, the storm was down to 968 mb. The ***Mathilde Maersk*** (48°N, 32°W) ran into the associated cold front and hit 49-kn westerlies at 0600 on the 20th. The ***Cumulus*** (56°N, 23°W) measured 42-kn southwesterlies in 17-ft swells at 1200. Four hours later swells were up to 23 ft. While the storm began to weaken on the 20th, it maintained a central pressure between 968 mb and 975 mb for the next several days as it brushed southern Iceland and recurved into the Greenland Sea east of Iceland.

Casualties– According to the Coast Guard at least eight vessels sank in the March Blizzard (Monster of the Month). On the 13th at about 2025, the mv ***Fantastico*** sank about 70 mi south southwest of Fort Myers, Fl. The 10-member crew abandoned the 205-ft Honduran vessel in 30-ft seas and 50-mph winds. Three crew members died before the rescue helicopters arrived and plucked three others to safety. Four were missing. The vessel ***Gypsy*** sank on the 12th about 60 mi south of Freshwater Bayou, LA, but the five people on board were rescued by a helicopter from Air Station Houston (USCG). The ***Lance*** sank 50 mi south of Morgan City, LA, but the three people on board were rescued by the ***Catrin***. The tug ***Adrienne L.*** sank in Mobile Bay on the 12th, and its crew was rescued.

The fully loaded ***Gold Bond Conveyor*** was enroute from Halifax, Nova Scotia to Tampa, Fl on its regular gypsum ore run when it hit the storm shortly after midnight on the 14th. At about 12:20 a.m. the captain radioed that waves were breaking over the bow, and the crew was abandoning the 584-ft vessel. Winds in the area were estimated at 80 mph with swells to 65 ft. The vessel went down some 110 mi southeast of Cape Sable Is. One body was eventually recovered along with two empty life rafts. The other 32 crew members were listed as missing.

On the 29th it was reported that the ro- ro mv ***St. Rognvald*** sailing from Lerwick for Aberdeen with 19 persons on board was hit by large seas and sustained damage to the wheelhouse and the bridge windows were caved in.

All times unless noted are UTC (universal time) and all miles are nautical. For additional detail, tropical cyclones will be covered in the annual reports from the tropical cyclone centers around the world. The weather summaries are based upon the track charts and Northern Hemisphere Surface Charts as well as ship reports and attempt to highlight the most significant ocean features each month. The track charts are provided by NOAA's National Meteorological Center. If an extratropical storm is particularly bad for shipping, we may designate it as the Monster of the Month.

–ed.

North Pacific Weather January, February, and March 1993

January–The Aleutian Low was less extensive and weaker than normal, resulting in positive pressure anomalies over the northern shipping lanes. The subtropical high was also weaker than normal. As a result, winter storm tracks in January were spread out across the Pacific north of about 25°N. The good news is that most were of weak to moderate intensity. During the first half of the month, a flurry of weak Lows from Southern California west southwestward to about 165°W helped keep pressure in these waters below normal. During this same period, western North Pacific Lows tended to move northward and north northeastward.

One storm of note during the first 2 weeks of January developed over Honshu on the 7th. By the 8th its central pressure was down to 973 mb. At 0000 on the 9th, the ***Jade Forest*** (45°N, 168°E) reported a south southwest wind at 58 kn and a 986-mb pressure while the ***Century Highway No. 29*** (50°N, 164°E) was battling 53-kn northerlies in 17-ft swells. Some 6 hrs later it was battling 26-ft swells. As the storm moved into the Bering Sea on the 10th, it began to weaken.

On the 15th, a Low developed along a front near 50°N, 167°W. After dipping southward, it headed toward the north northeast and combined with another system from the eastern Bering Sea. By 0000 on the 17th, its 966-mb center was approaching Kodiak Is. The ***Westwood Anette*** at this time was measuring 50-kn winds in 30-ft swells near 50°N, 156°W. Nearby, the ***Nada II*** ran into 48-kn south southwesterlies. The storm remained intense throughout the day as it moved across Kodiak Is and up Cook Inlet to the Alaskan mainland. At 0600 the ***Sea Bells*** (55°N, 152°W) ran into 20-ft seas while measuring 49-kn southerlies. The ***JKLS*** (55°N, 159°W) reported 43-kn northwest winds and a 968-mb pressure.

Known as the Inaugural Storm of 1993, this system began near 42°N, 147°W on the 18th. It crossed the Western Washington coast on the 20th as a 982-mb Low. When a Low moves north of Seattle from the southwest, forecasters are aware that it can create a significant pressure difference between Western and Eastern Washington. This intenifies easterly winds through the mountains and creates real problems in the Puget Sound area. Winds at Hood Canal gusted to 94 mph, while on the roof of the University of Washington's Atmospheric Sciences building, a gust of 88 mph was measured. Gusts of 60 to 75 mph were common throughout the Seattle area and winds caused power outages for some 750,000 residents. The Evergreen Point Floating Bridge across Lake Washington was closed during the morning commute.

This transPacific storm came to life south of Tokyo on the 18th. It went relatively unnoticed for the first few days as it paralleled Japan and the Kuril Is. On the 21st it crossed the 45th parallel near 165°E on an east northeast heading. On the 22nd and 23rd, the center turned a counterclockwise loop and intensified. By 0000 on the 23rd, its pressure dropped to 960 mb. The ***Sea Bells*** (54°N, 170°E) battled 20-ft swells and measured 48-kn north northeasterlies. Several other vessels also reported winds in the 40-kn range while the ***Kure Maru*** (51°N, 165°E)

Japanese Earthquake

At approximately 1108 UTC on January 15, 1993, the ship experienced very heavy vibrations for about 10 seconds duration. Vibrations are a normal experience on a ship, but these were heavier than usual and certainly not normally experienced during a deep sea passage, unless something is wrong. The ***Fidelity*** is a container type vessel of 40,890 gross tons. At this time we were on passage from Long Beach, California to Hong Kong at 42° 02'N 144° 02'E in over 1,000 meters of water: No hard alteration, of course had been made, and all below was working normally, so at the time the cause was a mystery. This appeared to be solved shortly afterwards when a Japanese TV program that some Officers were watching was interrupted with the announcement that an earthquake had occurred south of the island of Hokkaido. At the time, we were 60 miles south of the port of Kushiro, a fishing port on the southeast coast of Hokkaido. In the January 27th issue of *Asiaweek*, a small article mentioned the earthquake, which had measured 7.5 on the Richter scale. Its epicenter was estimated about 20 miles south of the port of Kushiro, 150 miles below the sea bed.

Observers: Captain S.J. Ivey and crew, ***OOCL Fidelity***

hit 50-kn winds in 23-ft swells. The storm really hampered shipping throughout the 23rd. Winds up to 56 kn were reported and seas climbed to near 40 ft. The system remained potent through the 25th as it swung toward the southeast. At 0000 on the 24th, the ***3EBW4*** (44°N, 170°E) ran into 50-kn west northwesterlies in 25-ft swells; 3 hrs later swells were up to 30 ft. Throughout the 24th, winds in the 40- to 50-kn range were common and the ***3EBW4*** was taking a beating. At 1200 they measured 56-kn winds in 25-ft swells. On the 26th the storm with a 985-mb center recrossed the 45th parallel near 165°W. It deepened slightly as it moved northeast through the Gulf of Alaska and combined with another Low on the 29th. By the 30th it was ashore over southeastern Alaska.

Casualties– On the 19th, there was a report of heavy weather damage by the ***Mv Slavnoe*** from DeKastri to Toyama. It was also reported that the mv ***Marine Hawk*** sank 400 mi southwest of Ishigaki Is, Okinawa on the 28th in heavy seas. At least three of the eighteen crew members were reported dead with two others missing.

February– In contrast to the North Atlantic, the North Pacific's winter climatic Low was in fine fettle in February. It literally dominated the weather pattern north of 40°N and its 986-mb center compared to a normal near 1000 mb resulted in tremendous negative anomalies (down to -12mb) in the northwestern North Pacific. Pressures over the Gulf of Alaska were actually higher than normal reflecting a lack of strong cyclonic activity in these waters, particularly during the second half of the month.

An obvious pattern for severe storms during the first half of February was a parabolic movement from off Honshu into the Bering Sea. The month opened with several moderate Lows dominating the weather across the Pacific north of 30°N. On the 2nd a large 968-mb Low was centered near 40°N, 145°W with a cold front that stretched back into the tropics through Hawaii. At 0300 on the 2nd, the ***Sapporo Maru*** (46°N, 144°W) ran into 48-kn north northeasterlies in 23-ft swells and a few hours later, the ***C6KR7 (46°N, 144°W)*** reported 52-kn northeasterlies while the ***Sapporo Maru*** measured 50-kn winds. Both were battling 26-ft swells. Central pressure in this storm dropped to 960 mb by 1200, and its large circulation extended to the northwest Pacific coast. The center was actually in the process of turning a counterclockwise loop before heading northward and weakening. At 1200 the ***A8GJ*** (47°N, 155°W) hit 55-kn northeasterlies while being pounded by 35-ft swells. An interesting feature of this storm was the number of reports of 35- to 40-ft swells within 400 mi north and northwest of the center on the 2nd. In addition, the ***XPJOX*** ran into a 33-ft swell in 50-kn winds some 500 mi south of the center.

During the same period a small but potent 968-mb Low was creating a few problems near 40°N, 170°E. The ***President Eisenhower*** (40°N, 177°E) ran into 45-kn

southerlies in 30–ft swells while the ***Emma Oldendorff*** (43°N, 173°E) punched in with a 51–kn southeasterly in 17–ft seas. At 0000 on the 3rd, the ***JQVV*** (42°N, 180°) was blasted by a 55–kn southerly in 33–ft swells as this storm began to recurve after crossing the 45th parallel. Both systems weakened significantly by the 4th.

A potent storm came to life on the 7th east of northern Honshu. It deepened rapidly as it headed toward the east northeast. By 1200 on the 8th, it was sporting a 956–mb center and within 24 hrs that was down to 942 mb, and the system was recurving over the western Aleutians. The western shipping lanes were being bombed. At 1200 on the 8th, the ***Sea Land Spirit*** (36°N, 145°E) was shelled by 50–kn westerlies in 33–ft swells and 6 hrs later the ***Green Kobe*** (42°N, 162°E) measured 60–kn winds in 17–ft seas. The bombardment continued on the 9th , when in 20–ft seas the ***Marit Maersk*** (42°N, 180°) measured 57–kn winds in moderate rain showers. Farther north the ***Westwood Anette*** (53°N, 173°E) in snow showers which were reducing visibility to less than 50 yards battled 53–kn east southeasterlies in 13–ft seas. The biggest waves were being reported throughout the day by the ***WSRL*** (41°N, 174°E) which rolled in 33–ft swells. The 10th did not bring much of an improvement in conditions as the system meandered westward through the Aleutians. Gales were being reported up to 800 mi to the south of this 955–mb center. It began to weaken on the 11th, but it wasn't until the following day that conditions really improved.

By his time another storm over the central North Pacific was intensifying and recurving. At 1200 on the 11th, its 962–mb center had crossed the 45th parallel near 165°W and was turning toward the tip of the Alaska Peninsula. The storm was generating storm force winds and 10–to 20–ft seas. The ***Westwood Jago*** was battling 50–kn winds and 26–ft swells on the 11th and the 12th in the vicinity of 43°N, 165°W. In 23–ft seas, the ***Shaubryn*** (40°N, 161°N) hit 52–kn winds at 1200 on the 11th. On the 13th the weakening storm moved across Unimak Is and into the Bering Sea.

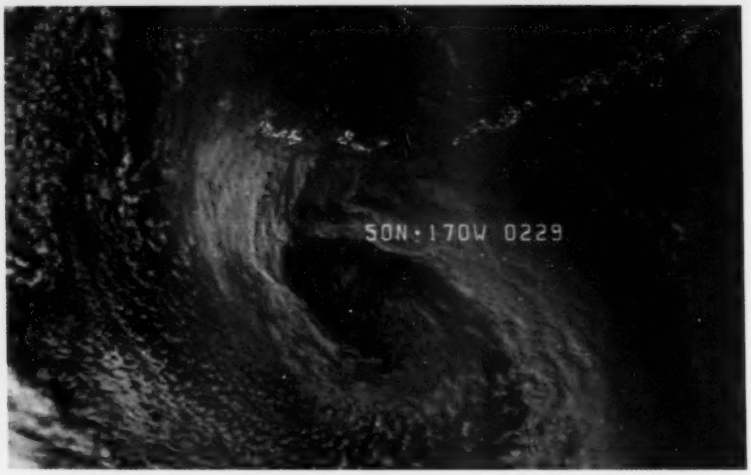
The second half of the month saw two storms that were particularly intense. A Low which had developed over Northern Honshu on the 13th headed east northeastward and intensified. By the 15th, its 966–mb center crossed the 170°E meridian near 45°N. The storm was at its peak intensity on the 15th and winds of 40 to 45 kn were common. At 1200 the ***McKinney Maersk*** measured 48–kn westerlies in 15–ft seas. Gales continued on the 16th, but pressure was already rising.

During the last week of the month mariners had to battle a double–header. Actually, this huge complex circulation had several identifiable centers. On the 25th a 965–mb center was located near 45°N, 170°E, a 967–mb center was located near 50°N, 175°W, and a 968–mb center was found at about 55°N, 175°W. The circulation covered most of the Pacific between the Kurils and the Gulf of Alaska. The two westernmost centers were moving east northeastward while the one in the Bering Sea had already moved across the Pacific and was in the process of turning a counterclockwise loop. At 1800 on the 25th, the ***KIRF*** (37°N, 174°E) was racked by 46–kn westerlies in 30–ft swells while 12 hrs later the ***GYAB*** (33°N, 162°E) battled 26–ft swells in 40–kn winds. By the 27th three centers were still recognizable and the huge circulation dominated most of the North Pacific with winds in the 30– to 40–kn range. Conditions improved on the last day of the month.

Casualties– It was reported on the 5th that both the ***Ever Living*** and ***Hanjin Seattle*** lost containers in heavy weather in the Pacific. In stormy weather on the 20th in the East China Sea, the 80–ton ***Ebisu Maru No. 7*** with 20 people aboard capsized. One crew member was rescued by another fishing vessel, but 19 others were missing and feared trapped inside. The boat was the leader of a six vessel convoy. The rescued crewman said that he and the deck chief were thrown overboard when the vessel capsized. The skipper and two officers were in the cabin and the others were sleeping below when the boat began to tilt. Officials said that the sea was not rough enough to capsize a fishing vessel of this size but suspected a "triangular wave." Such waves as high as 24 ft are caused by a combination of currents and winds.

It was reported on the 23rd that the cement carrier ***Ryonan Maru*** and the cargo vessel ***Zhong Shar Men*** collided in rough seas some 2.5 miles south of Nagata in the port of Kobe. The ***Ryonan Maru*** sank later and eight of the crew of thirteen were rescued.

March–The Aleutian Low was a little deeper than normal on the climatic chart and extended farther southeast than usual. This resulted in an area of 4– to 6– mb negative anomalies between southeast Alaska and Hawaii. This is reflected in the track chart which shows a number of moderate Lows moving through these waters and into the Gulf of



Sattelite Data Services Division

This NOAA 11 satellite shot was take over the Aleutians on the 2nd of March at about 0230.

Alaska.

The first week of the month saw a series of Lows form in the mid Pacific, move east northeastward, and then recurve into the Gulf of Alaska. In fact, from the 4th through the 6th three Lows combined southeast of the Kodiak Is after traversing the mid Pacific. On the 2nd a 988-mb Low centered near 40°N, 170°E was causing some real problems. At 1200 the ***Morelos*** (42°N, 157°E) ran into 48-kn westerlies while the ***Nosac Express*** (45°N, 152°E) reported 45-kn winds, and the ***Valdivia*** (54°N, 169°E) in 44-kn winds battled 17-ft seas. Conditions were bad the following day as well. At 0600 on the 3rd, the ***Skaubryn*** measured 56-kn westerlies near 44°N, 156°E. During the next 10 days or so, a series of small to moderate systems moved across the Pacific flaring up briefly and then sputtered. It wasn't until the 13th that a real blockbuster showed up.

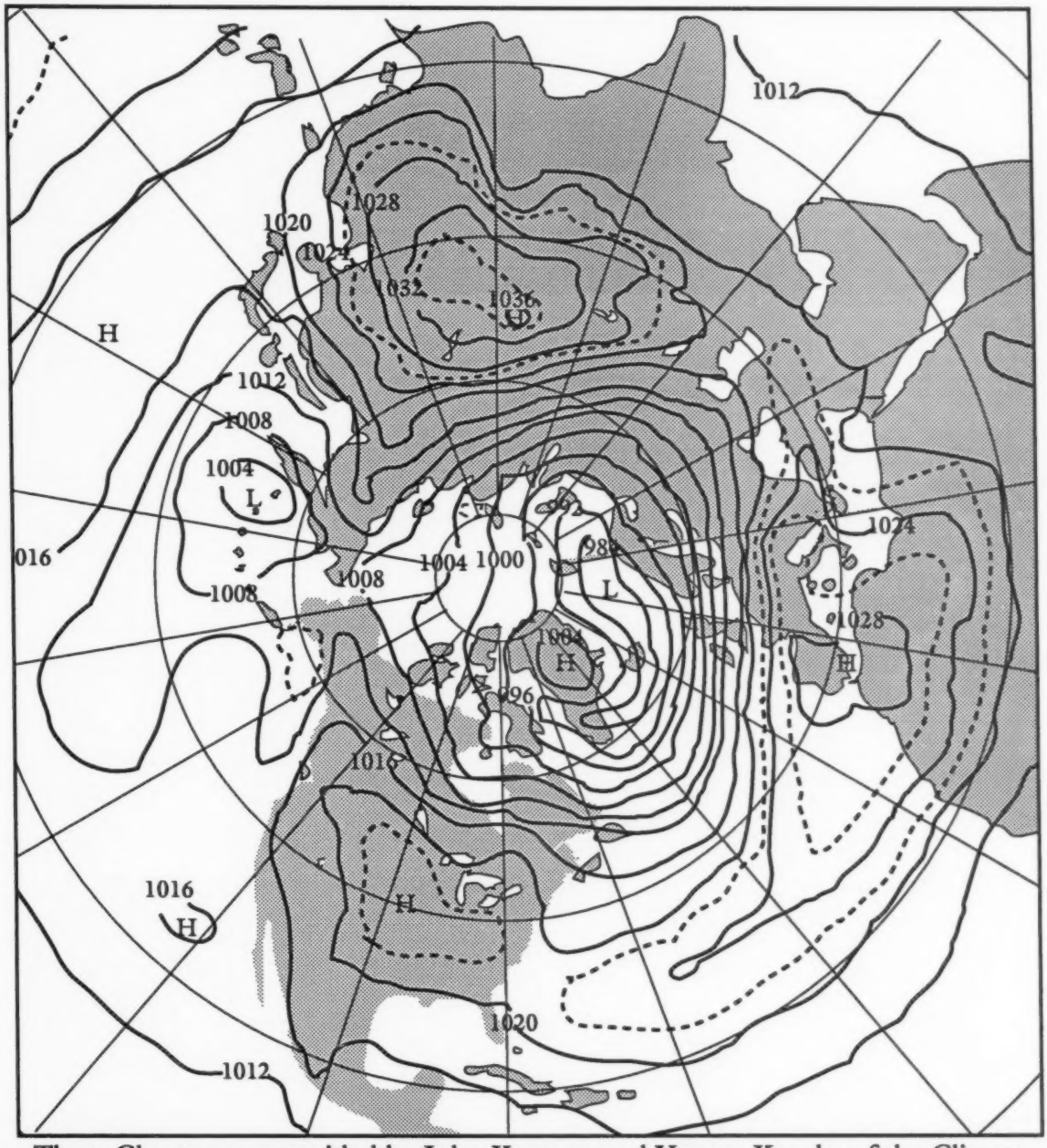
This system came to life on the 11th, southwest of Tokyo. At 1200 on the 12th, its central pressure was 991 mb and within 24 hrs it was estimated at 960 mb. By 0000 on the 14th, it was down to 953 mb and heading northeastward. Within 600 mi of the center, winds were blowing at 40 to 50 kn. Seas were roughest south of the center where 20- to 30-ft swells were being reported. The ***Simara Express,*** 300 mi east of the center at 0000 on the 14th, encountered 50-kn winds in 20-ft seas. Although the system stalled and began to fill on the 15th, it remained potent for a short time. On the 15th at 0000 the ***ELKF8*** (54°N, 178°E) measured a 50-kn northeasterly in 20-ft swells. However, by 1200 the system was really starting to weaken.

This storm came to life on the 18th south of Tokyo. It slowly intensified as it headed east northeastward across the Pacific. It crossed the Dateline near 41°N as a 990-mb Low and continued to strengthen. The real deepening took place on the 22nd. At 1200 on the 21st, its pressure was estimated at 986 mb. Within 24 hrs it fell 36 mb to 950 mb. At 1500 the ***Miller Freeman*** (57°N, 155°W) measured 45-kn easterlies in 15-ft swells. By the 23rd the system moved ashore as a 964-mb Low east of Cordova.

On the 24th, a 958-mb center was analyzed near 46°N, 180° at 1200. This was a drop of 36 mb in 24 hrs. Two days later in this same area another Low dropped from 971 mb at 1200 on the 25th to 952 mb 24 hrs later. This meant two potent storms dominated the North Central Pacific during this period. Ships such as the ***Polydefkis P*** and the ***Skaubryn*** were reporting winds in the 40- to 45-kn range in 10- to 20-ft seas. On the 25th at 0300, the ***JPGO*** (54°N, 158°W) ran into 20-ft swells in 40-kn winds. Conditions eased on the 27th, but the month finished out with a bang. A 986-mb Low at 1200 on the 29th near 42°N, 165°E moved northeastward and exploded. By the 30th at 1200, its central pressure had plummeted to 962 mb and continued falling. It hit 954 mb at 0000 on the 31st as it moved through the Aleutians. The ***Papyrus*** (55°N, 164°W) was belted by 53-kn winds in 21-ft swells at 0600 on the 30th. By the 31st at 0000, this vessel was running in 26-ft seas but continued to report.

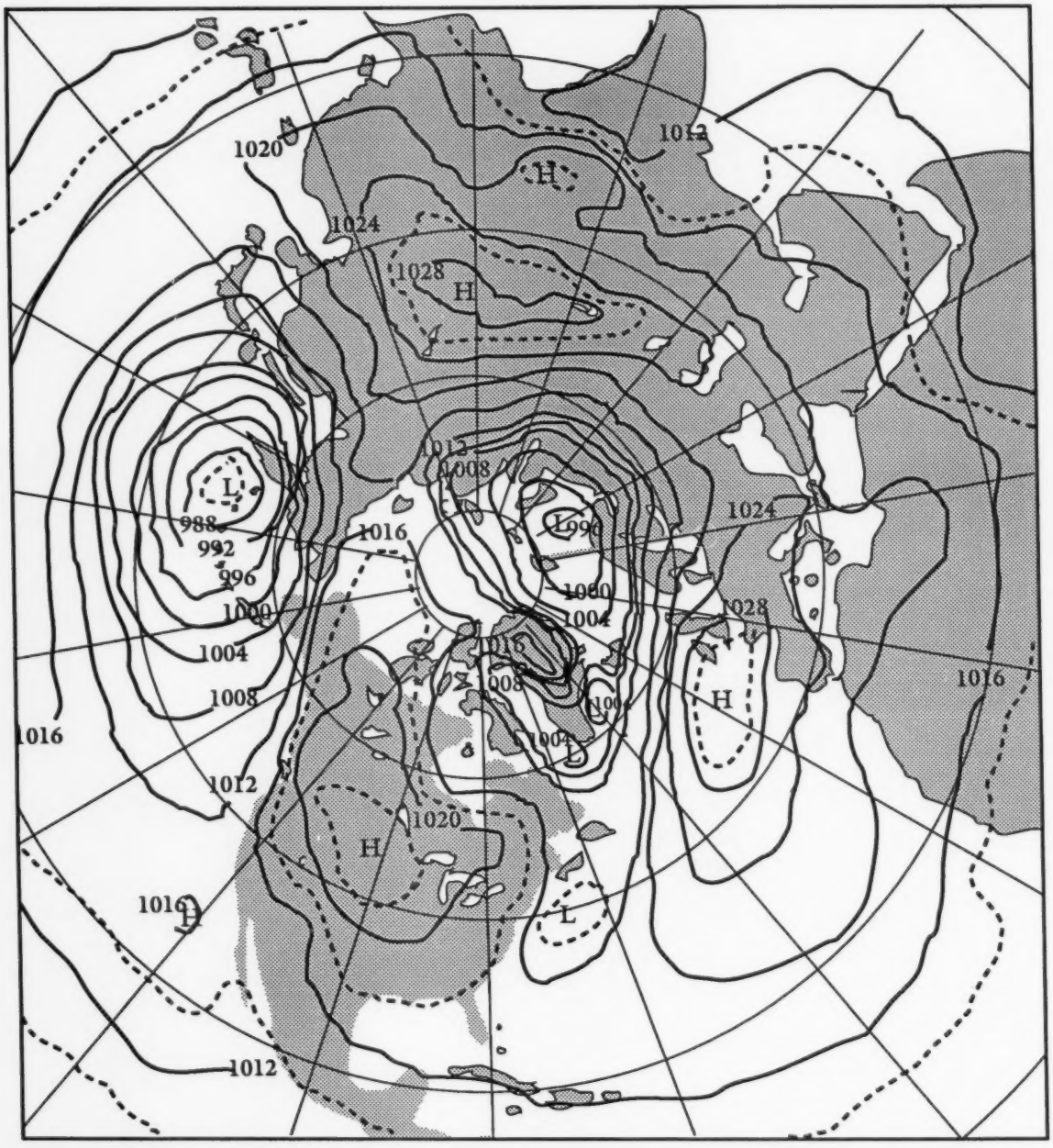
Casualties— On the 25th, bodies of 16 men believed to be the crew of the missing mv ***Xian Ren*** were found by a fishing vessel while another body and a lifeboat was found near an oil slick. The man was wearing a life jacket with the name of the missing vessel. The vessel was reporting missing off Shikoku after entering an area of high winds and rough seas. It is now believed that the 4,047-ton ***Xian Ren*** sank in heavy seas and 17 crew members are dead with 12 others missing. In Bangladesh on the 26th, about 250 people were feared drowned when a storm stuck an overcrowded ferry in the Tetulia River. The vessel went down within minutes.

January 1993



These Charts were provided by John Kopman and Vernon Kousky of the Climate Analysis Center from the Climate Diagnostics Bulletin

February 1993



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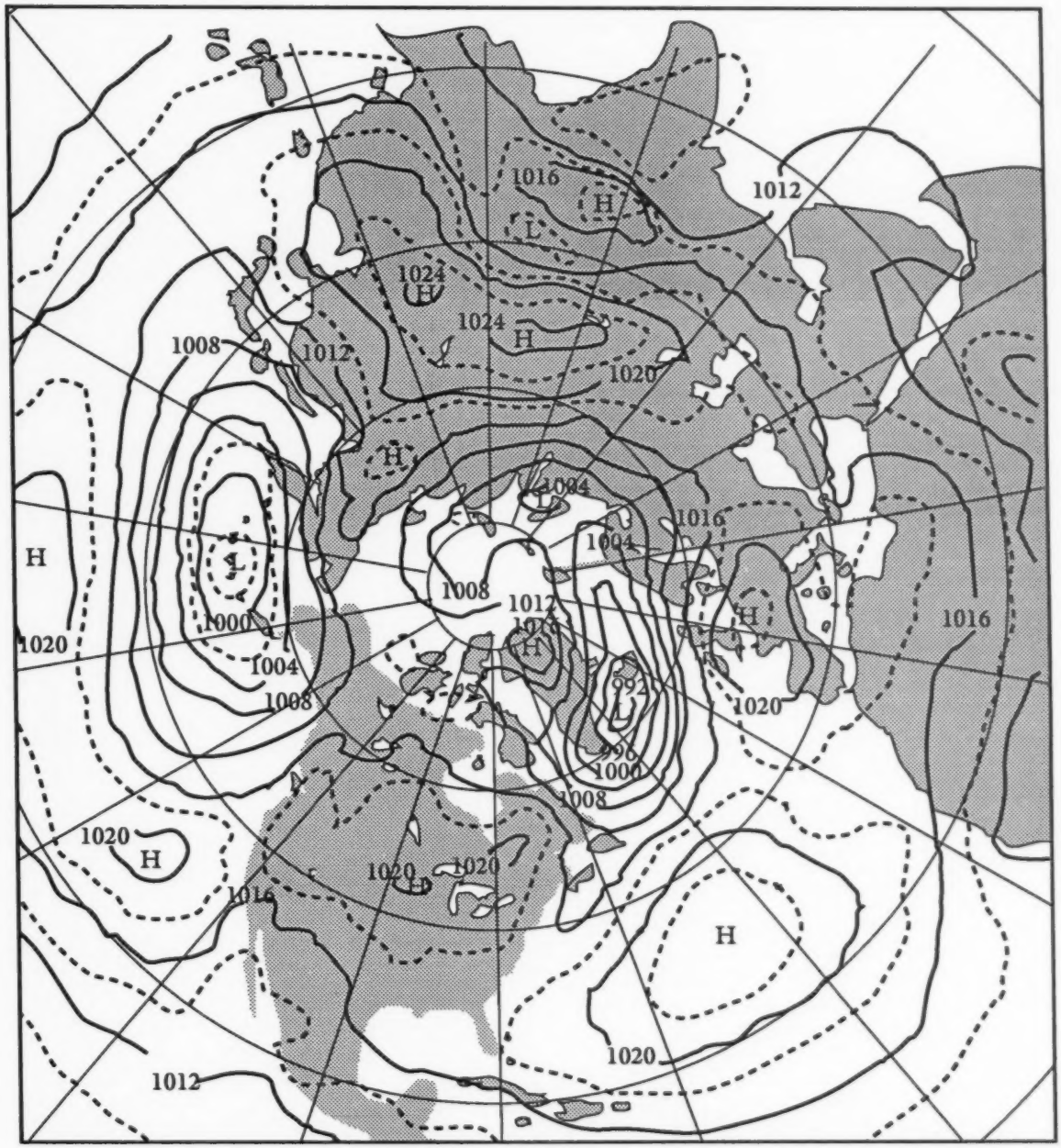
March 1993



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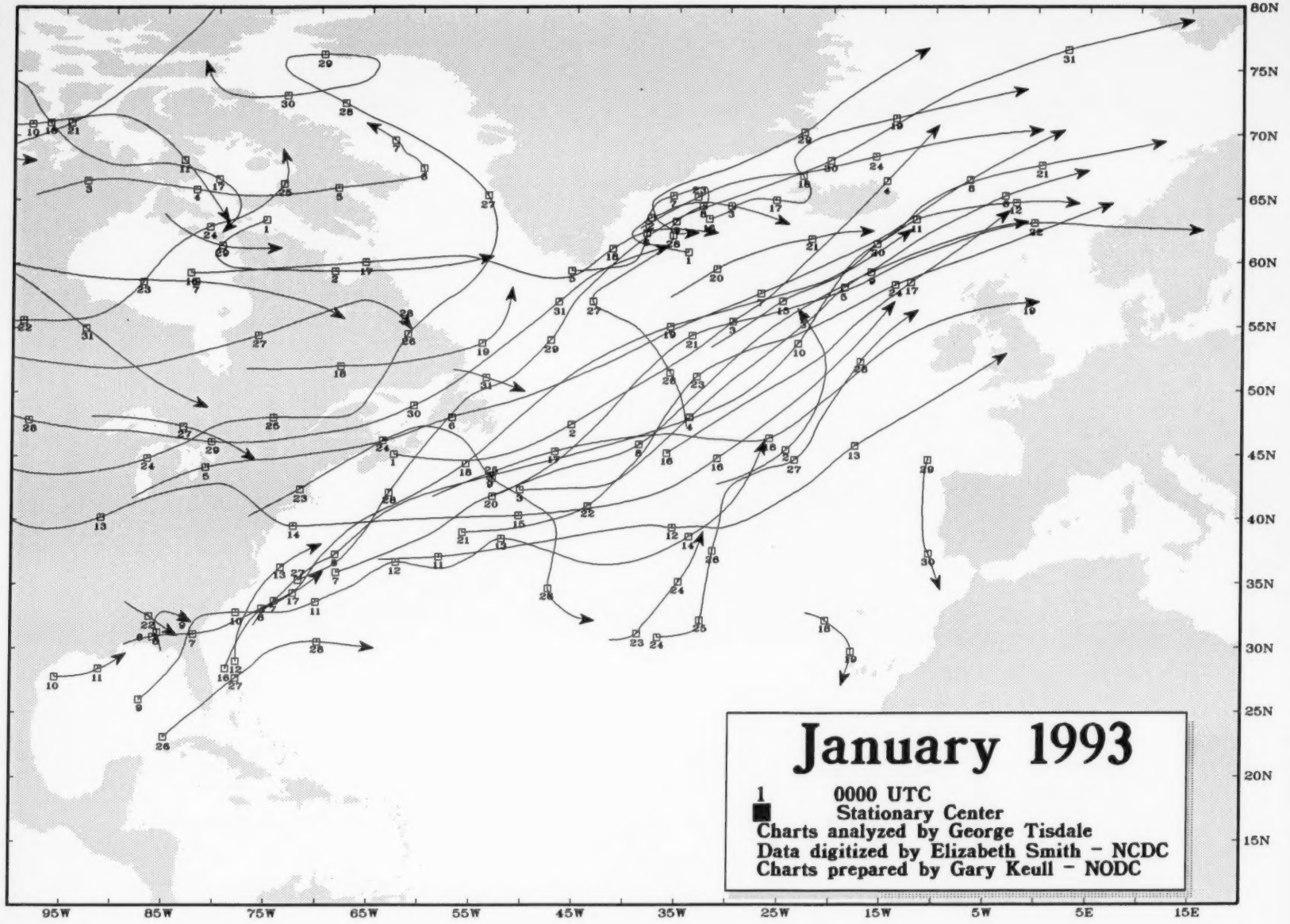
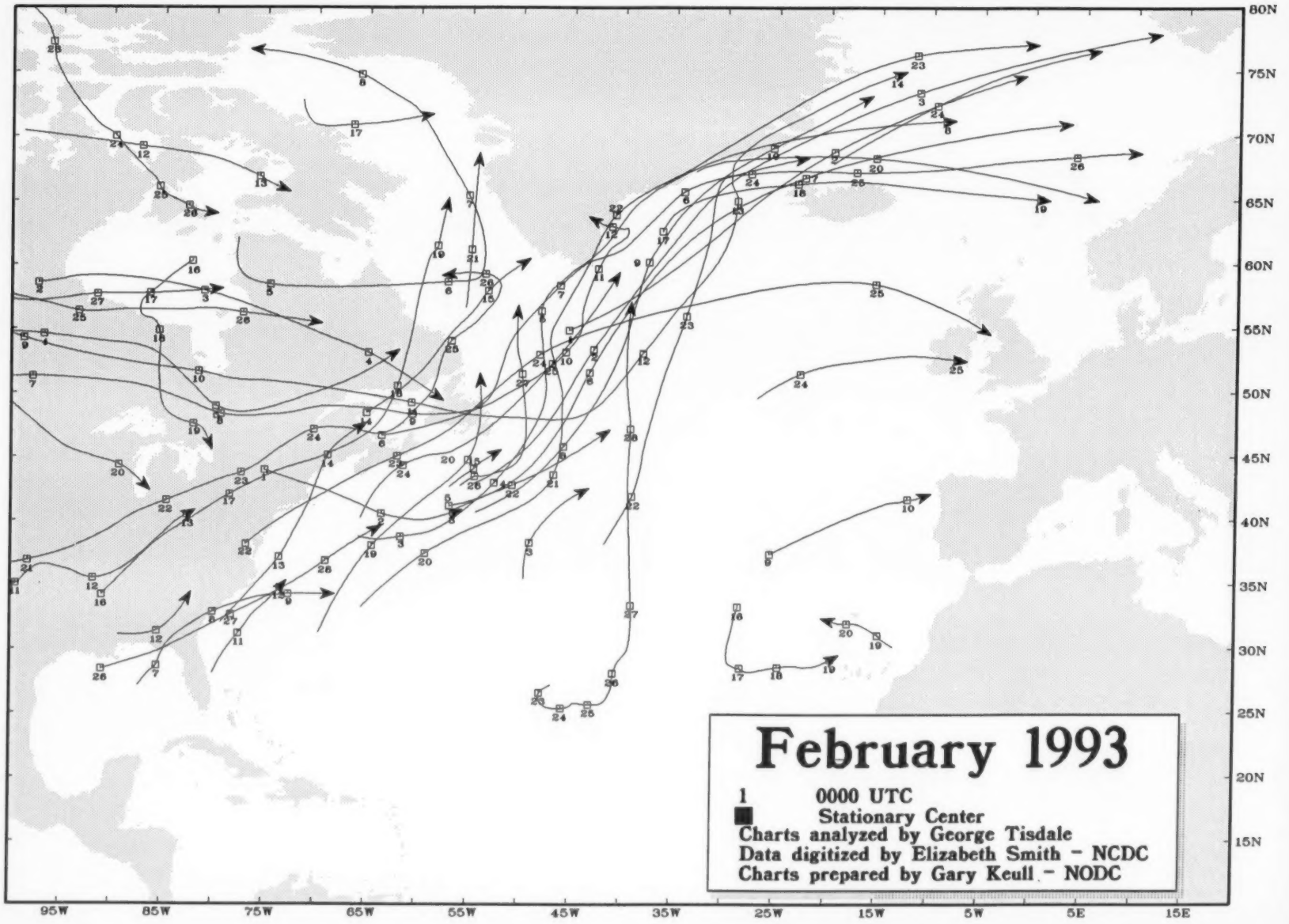
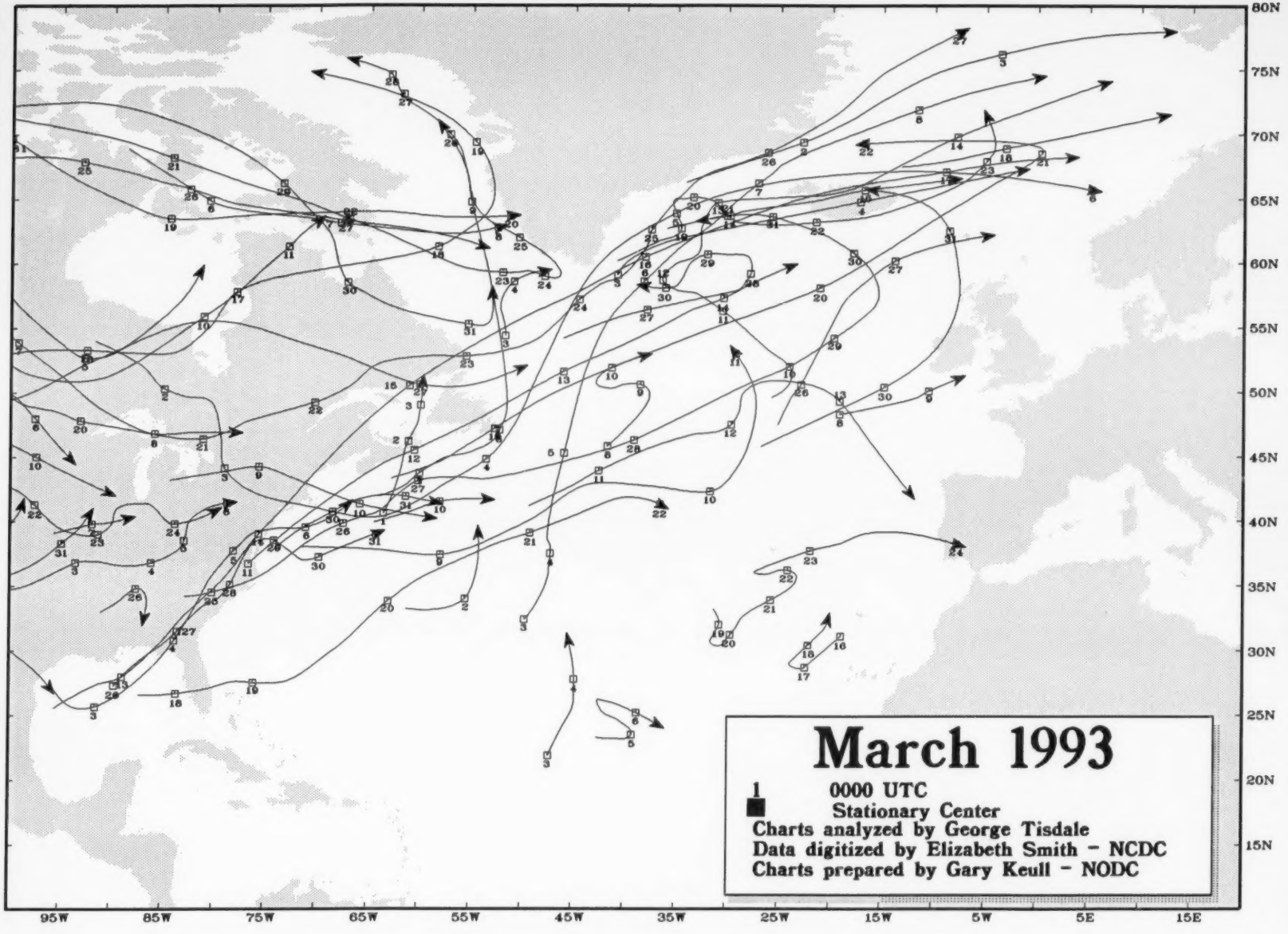
Principal Tracks of Cyclone Centers at Sea Level, North Atlantic



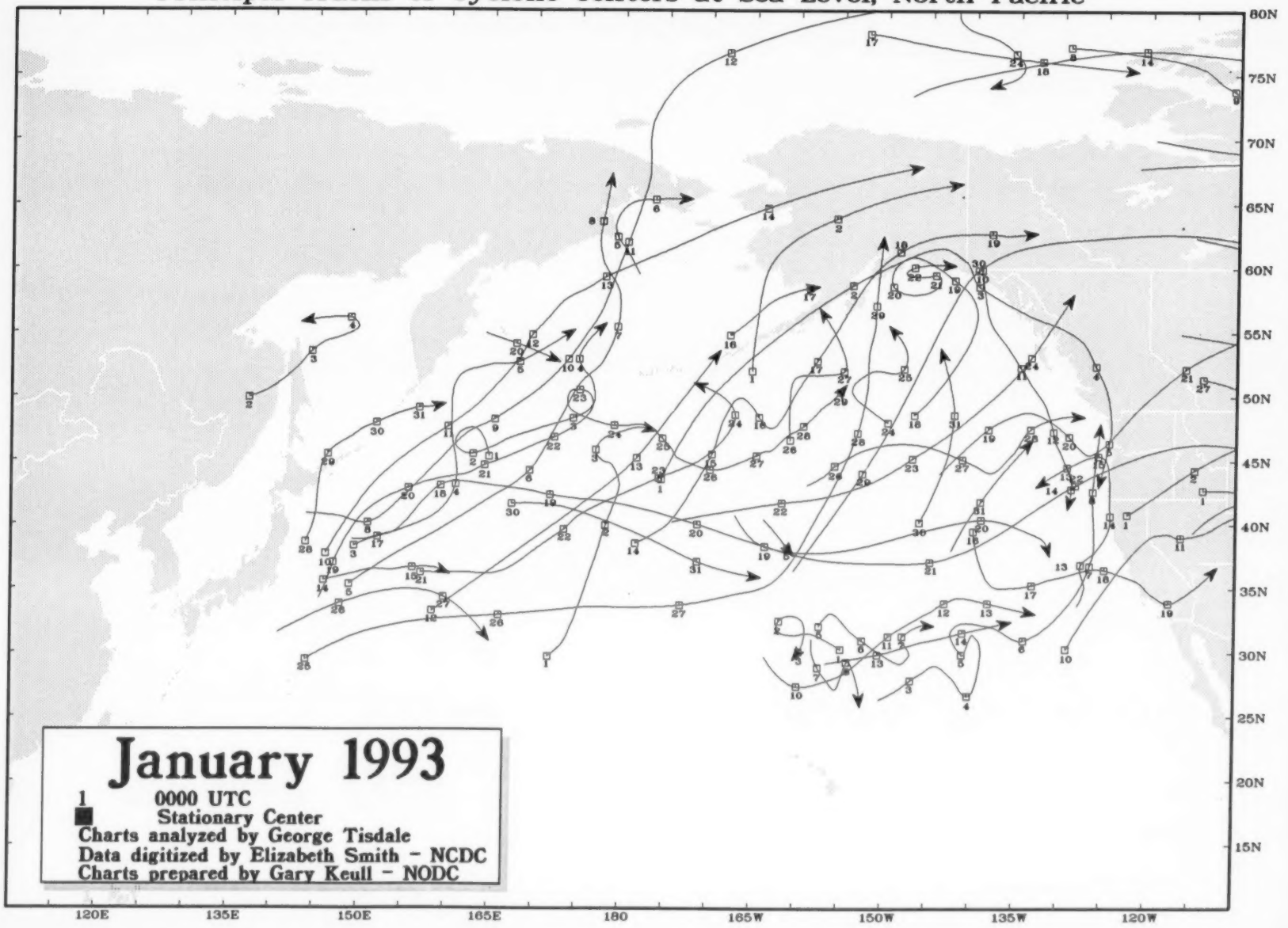
Principal Tracks of Cyclone Centers at Sea Level, North Atlantic



Principal Tracks of Cyclone Centers at Sea Level, North Atlantic



Principal Tracks of Cyclone Centers at Sea Level, North Pacific



January 1993

1 0000 UTC

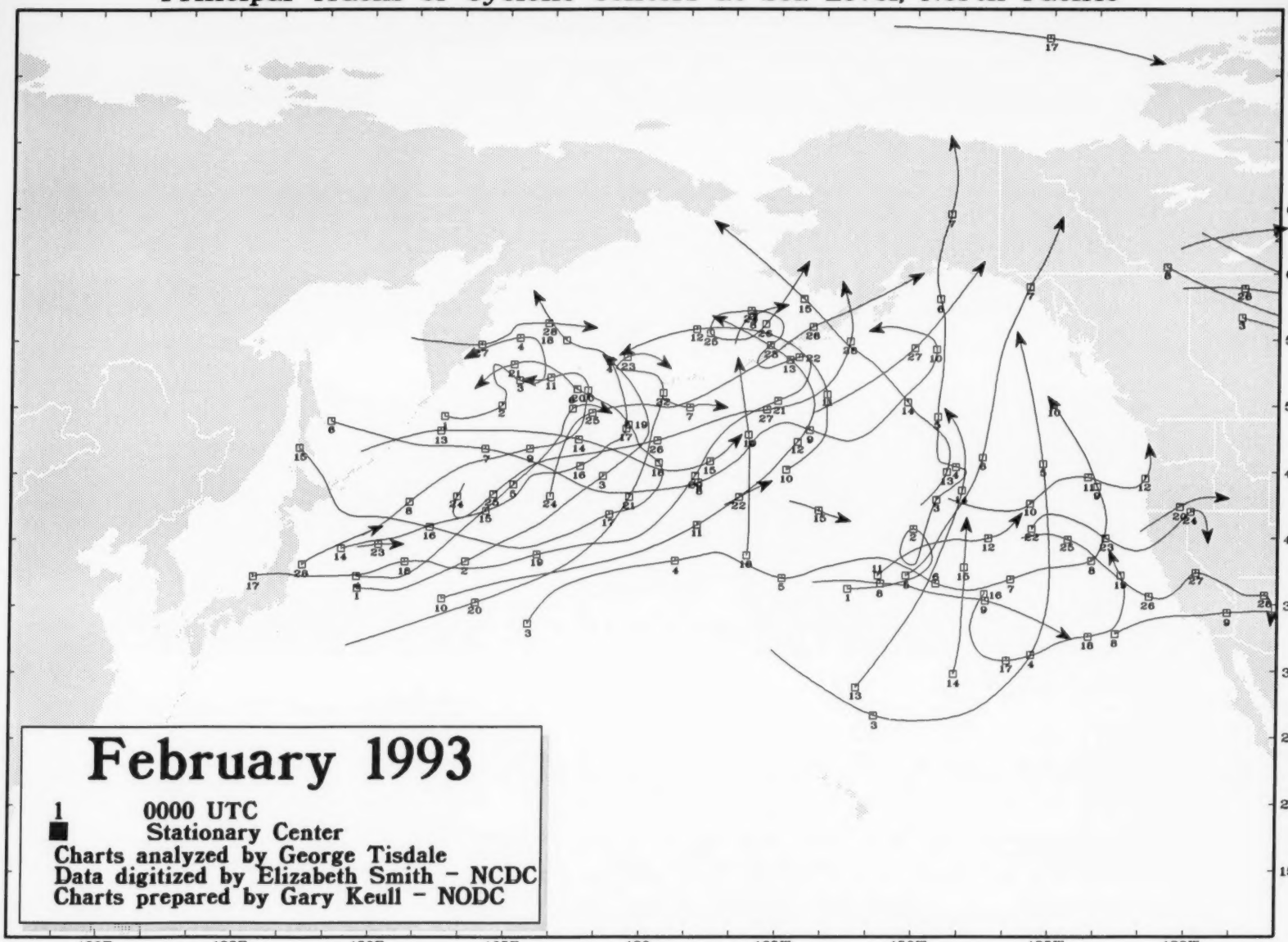
■ Stationary Center

Charts analyzed by George Tisdale

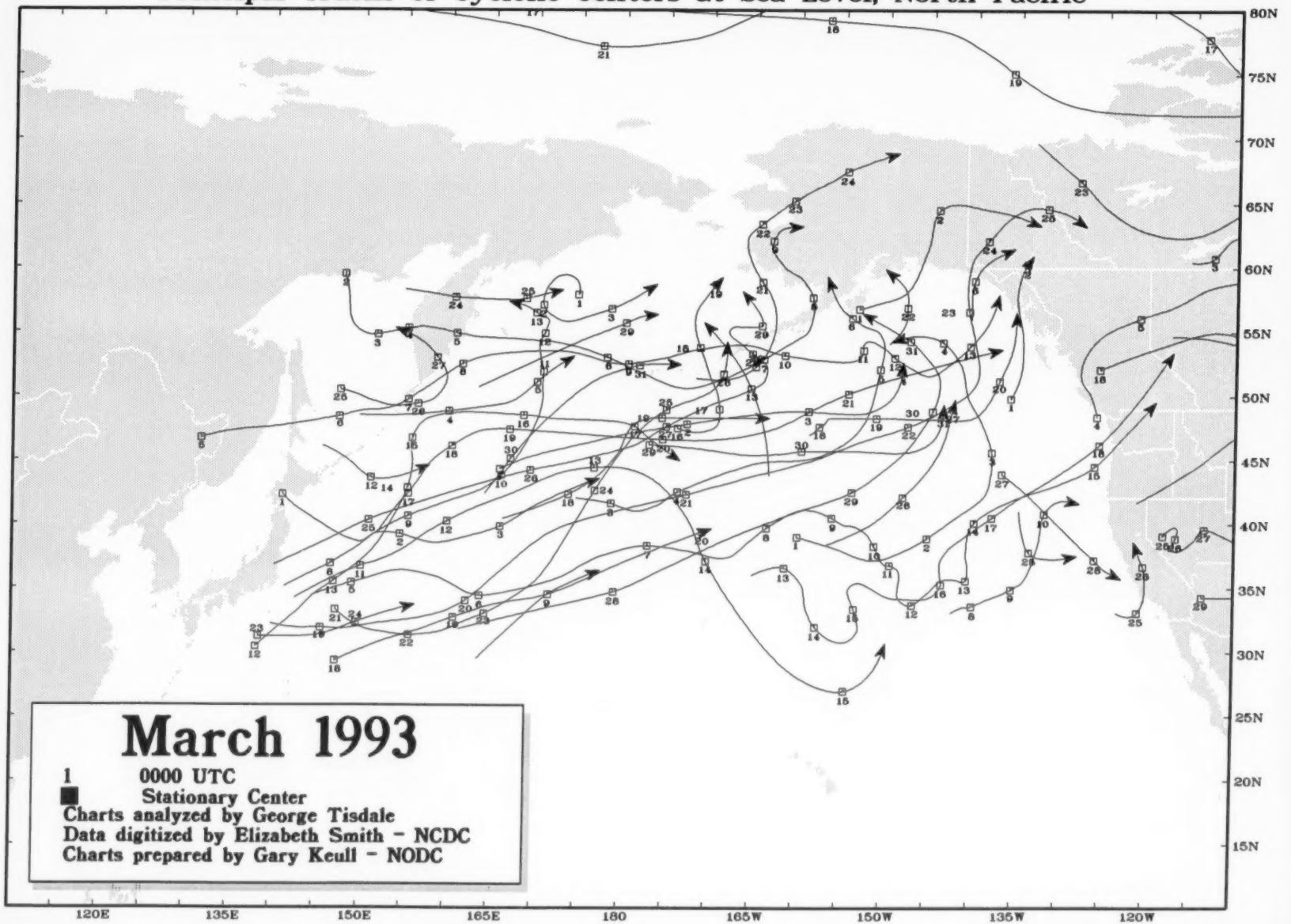
Data digitized by Elizabeth Smith - NCDC

Charts prepared by Gary Keull - NODC

Principal Tracks of Cyclone Centers at Sea Level, North Pacific



Principal Tracks of Cyclone Centers at Sea Level, North Pacific



January, February, and March 1993

	RADIO	MAIL
1ST LT ALEX BONNYMAN	37	38
2ND LT. JOHN P. BOBO		8
A. V. KASTNER	79	
ACADIA FOREST	166	64
ACE ACCORD	33	
ACONCAGUA	4	
ACT 7	257	
ACT I	82	
ADABELLE LYKES	64	146
ADRIAN MAERSK	28	
ADVANTAGE	53	135
AFRIC STAR	2	
AFRICAN CAMELLIA	64	
ALASKA RAINBOW	65	58
ALBERT MAERSK	22	56
ALBERTO TOPIC	19	
ALDEN W. CLAUSEN	30	22
ALLIGATOR COLUMBUS	47	50
ALLIGATOR EXCELLENCE	86	
ALLIGATOR FORTUNE	42	
ALLIGATOR GLORY	61	69
ALLIGATOR HOPE	79	51
ALLIGATOR JOY	79	28
ALLIGATOR LIBERTY	143	
ALLIGATOR TRIUMPH	60	67
ALMERIA LYKES	2	6
ALPENA	12	
ALTAMONTE	32	
AMER HIMALAYA	11	
AMERICA STAR	186	
AMERICAN CONDOR	3	
AMERICAN CORMORANT	13	
AMERICAN EAGLE	29	32
AMERICAN FALCON	70	19
AMERICAN KESTREL	42	
AMERICAN MARINER	9	
AMERICANA	60	56
AMERIGO VESPUCCI	36	77
ARABIAN SENATOR	64	
ARCO ALASKA		13
ARCO ANCHORAGE	24	29
ARCO CALIFORNIA		48
ARCO FAIRBANKS	19	9
ARCO SAG RIVER	1	22
ARCO SPIRIT	15	10
ARCO TEXAS	13	44
ARCTIC OCEAN	155	158
ARCTIC TOKYO	38	154
ARGONAUT	53	131
ARIES	6	
ARILD MAERSK	30	2
ARNOLD MAERSK	12	63
AROSIA	4	
ARTHUR MAERSK		65
ASHLEY LYKES	38	
ASIAN SENATOR	264	
ASPEN	12	37
ASTERIKS	57	
ATIGUN PASS	3	
ATLANTA BAY	33	
ATLANTIC CARTIER	78	
ATLANTIC COMPASS	67	
ATLANTIC CONVEYOR	110	
ATLANTIC OCEAN	49	
ATLANTIS II	6	
ATLAS HIGHWAY	8	
AUSTRAL RAINBOW	45	76
AXEL MAERSK	4	97
AYA II	164	
B.T. ALASKA	76	177
BALTIMORE TRADER	64	159
BARBARA ANDRIE	10	
BAY BRIDGE	110	113
BEBEDOURO	44	
BETTY GALE,USA	4	4
BIBI	96	
BLUE HAWK	8	
BOB L	1	
BOGASARI LIMA	272	
BOHOL SAMPAGUITA	18	
BONN EXPRESS	56	
BRIDGETON	2	
BRIGIT MAERSK	19	32
BROOKS RANGE	31	
BRUCE SMART	36	
BURNS HARBOR	35	40
CALIFORNIA CERES	76	
CALIFORNIA HERMES	74	
CALIFORNIA ORION	86	89
CALIFORNIA PEGASUS	65	
CALIFORNIA STAR	124	48
CALIFORNIA TRITON	114	
CALIFORNIA ZEUS	54	
CANADA EXPRESS	27	
CAPE HENRY,USA	54	92
CAPE MAY	127	
CARIBBEAN EMERALD	8	56
CARIBE 1	5	53
CARINA	21	78
CARLA A. HILLS	151	238
CARMEL	10	45
CARNIVALE	41	43
CAROLINA	11	65
CARTAGENA	216	71
CASON J. CALLAWAY	12	40
CASSIA	42	48
CATHAY SPIRIT	12	
CEDRELA	43	22
CENTURY HIGHWAY #2	114	86
CENTURY HIGHWAY NO. 5	69	
CGM ILE DE FRANCE	121	56
CGM LORRAINE	6	
CGM PROVENCE	84	
CHAITEN,LIBERIA	34	10
CHARLES B. RENFREW	2	
CHARLES M. BEEGHLEY	1	
CHARLESTON	5	7
CHARLOTTE LYKES	46	40
CHEMICAL PIONEER	147	120
CHERRY VALLEY	36	
CHESAPEAKE TRADER	16	19
CHESNUT HILL	21	42
CHEVRON BURNABY	118	
CHEVRON CALIFORNIA	89	92
CHEVRON COLORADO	69	90
CHEVRON COPENHAGEN		52
CHEVRON EDINBURGH	12	29
CHEVRON FELUY		217
CHEVRON HORIZON		147
CHEVRON MISSISSIPPI	127	103
CHEVRON PACIFIC	77	176
CHEVRON STAR		190
CHEVRON SUN		210
CHEVRON WASHINGTON	55	83
CHIQUITA BOCAS	28	
CHIQUITA CINCINNATION	134	207
CHIQUITA MILANO		40
CHIQUITA MILANO,BAHAMA	28	
CHOAPA	42	66
CLEMENTINA	22	
CLEVELAND	49	122
CO-OP EXPRESS III	25	
COAST RANGE	66	90
COLIMA		134
COLUMBIA STAR	42	
COLUMBINE	12	
COLUMBUS	46	
COLUMBUS AMERICA	333	
COLUMBUS AUSTRALIA	77	
COLUMBUS NEW ZEALAND	165	
COLUMBUS OHIO	34	30
COLUMBUS OLIVOS	16	
COLUMBUS QUEENSLAND	106	
COLUMBUS VICTORIA	198	
COLUMBUS VIRGINIA	186	
COLUMBUS WELLINGTON	185	
COMPANION EXPRESS	108	
CONCERT EXPRESS	84	
CONTIENTAL WING	66	
CONTSHIP AUSTRALIA	103	
CORAH ANN	88	80
CORNUCOPIA	73	147
CORONADO	47	86
CORPUS CHRISTI	55	179
COURIER	15	
COURTNEY L.	118	140
CRISTOFORO COLOMBO	18	47
CROWN PRINCESS,LIBERIA	79	96
DAN MOORE	2	
DANIELLA	86	
DAWN PRINCESS	4	
DEL MONTE TRADER,MONRO	7	99
DELAWARE TRADER	67	148
DEPPE AMERICA	7	
DIANA	11	22
DIRECT FALCON	145	
DIRECT KIWI	3	
DIRECT KOOKABURRA	144	164
DOCTOR LYKES	39	
DON JORGE	26	
DSR BALTIC	104	
DSR OAKLAND	106	
DSR YOKOHAMA	12	
DUSSELDORF EXPRESS	79	
DYVI OCEANIC	59	
EASTERN GLORY	7	
ECSTASY	145	165
EDGAR B. SPEER	20	21
EDWARD L. RYERSON	11	14
EDWIN H. GOTT	13	16
EDYTH L.		17
ELIZABETH LYKES	26	87
ELLEN KNUDSEN	57	
EMERALD SEA	31	76
EMMA OLDENDORFF,MONROV	156	127
ESPERANCE	8	
ESSO PALM BEACH	20	
ESSO PUERTO RICO	36	
EUROPEAN SENATOR	67	
EVER GAINING	22	12
EVER GARDEN	10	12
EVER GARLAND	18	4
EVER GATHER	14	
EVER GENTLE	13	39
EVER GIANT	16	11
EVER GIFTED	10	
EVER GIVEN	23	
EVER GLAMOUR	22	
EVER GLEAMY	16	
EVER GLEEFUL	24	
EVER GLORY	22	24
EVER GOING	18	42
EVER GOODS	27	26
EVER GOVERN	17	
EVER GRACE	5	
EVER GRADE	25	
EVER GRAND	7	
EVER GROUP	17	
EVER GROWTH	16	
EVER GUARD	41	
EVER GUEST	7	
EVER GUIDE	3	
EVER LAUREL	25	
EVER LEVEL	24	9
EVER LINKING	16	
EVER LIVING	22	
EVER LYRIC	17	
EXPORT FREEDOM	50	89

	RADIO	MAIL
EXPORT PATRIOT	52	140
EXXON BATON ROUGE	28	24
EXXON BENICIA	20	23
EXXON CHARLESTON	7	10
EXXON LONG BEACH		4
EXXON MEDITERRANEAN	6	16
EXXON NEW ORLEANS	31	
EXXON PHILADELPHIA	9	17
EXXON SAN FRANCISCO	12	13
FAIRLIFT	8	
FANTASY	43	31
FARNELLA	49	
FAUST	71	114
FEDERAL SKEENA	50	167
FERNCROFT	61	
FESTIVALE	4	
FETISH	138	29
FLORIDA RAINBOW	31	67
FOREST HAWK	102	84
FRANCES HAMMER	123	37
FRANCES L.	65	109
FRED G.	18	38
GALVESTON BAY	127	282
GEMINI	27	82
GEORGE H. WEYERHAEUSER	49	43
GEORGE WASHINGTON BRID	189	59
GEORGIA RAINBOW II	54	178
GERMAN SENATOR	2	
GERONIMO	2	
GLACIER BAY	9	
GLOBAL LINK	43	44
GLOBAL SENTENIAL	103	
GLORIOUS SPICA	100	
GOLD BOND CONVEYOR	54	
GOLDEN APO	25	
GOLDEN GATE BRIDGE	207	
GREAT LAND	46	339
GREAT RIVER	51	61
GREEN BAY	28	24
GREEN HARBOUR	22	
GREEN ISLAND	37	
GREEN KOBE	17	141
GREEN LAKE	114	121
GREEN RIDGE	81	48
GREEN SASEBO	32	110
GREEN SUMA	40	227
GREEN VALLEY	60	76
GREEN WAVE	14	
GUANAJUATO	130	44
GUAYAMA	17	30
GULF SPEED	117	
GYPSUM BARON	141	
GYPSUM KING	107	
HANEI SKY	19	82
HANJIN CHUNGMU	28	
HANJIN ELIZABETH	10	
HANJIN FELIXSTOWE	14	2
HANJIN HONG KONG	53	
HANJIN KAOHSIUNG	13	
HANJIN KEELUNG	16	
HANJIN KOBE	35	
HANJIN LE HAVRE	18	
HANJIN LONG BEACH	35	
HANJIN MASAN	34	
HANJIN NEW YORK	31	
HANJIN OAKLAND	17	28
HANJIN SAVANNAH	17	6
HANJIN SEATTLE	16	
HANJIN TONGHAE	21	
HANJIN VANCOUVER	6	
HANJIN YOKOHAMA	4	
HANSA LUBECK	28	
HANSA VISBY	36	
HEIDELBERG EXPRESS	97	
HENRY HUDSON BRIDGE	237	
HERMENIA	28	42
HOEGH CAIRN	32	
HOEGH CLIPPER	3	
HOEGH DUKE	10	
HOEGH DYKE	36	66
HOEGH MINERVA	25	93
HOLIDAY	12	12
HOWELL LYKES	76	137
HUAL ANGELITA	118	208
HUAL INGRITA	17	7
HUMACAO	79	174
HUMBER ARM	14	
HYUNDAI CONTINENTAL	56	
HYUNDAI DUKE	19	
HYUNDAI NO. 1	15	
IBN ZAIDOUN	4	
INDEPENDENT ACCORD	190	
INDEPENDENT SPIRIT	190	
INDIAN OCEAN	27	27
INFANTA	144	
INGER	60	123
ISABELLA	8	49
ISLAND PRINCESS	80	
ITB BALTIMORE	57	66
ITB NEW YORK	76	26
ITB PHILADELPHIA	34	40
IVER EXPLORER	22	
IVER EXPRESS	9	
J. DENNIS BONNEY		165
J.W. POWELL	24	
JACKSONVILLE	84	96
JAHRE SPIRIT	95	
JALISCO	96	122
JAMES LYKES	27	85
JAMES R. BARKER	7	
JAPAN CARRYALL	6	
JAPAN RAINBOW 2	70	75
JAPAN SENATOR	153	
JEAN LYKES	53	120
JEB STUART		93
JEZERA DELMAS,ST VINCE	9	33
JO BIRK	155	
JO LONN	38	
JOHN LYKES		2
JOHN V. VICKERS	242	71
JOHN YOUNG		108
JUBILEE	87	26
JULIUS HAMMER	2	12
JUPITER	17	
KAIMOKU	180	214
KAINULA	125	216
KAKUSHIMA	35	42
KAUAI	97	53
KAYE E. BARKER	11	
KEBAN		16
KEISHO MARU	52	
KENAI	70	159
KENNETH E. HILL	38	2
KENNETH T. DERR	32	
KENTUCKY HIGHWAY	22	
KEYSTONE CANYON	30	16
KEYSTONER	48	133
KOKUA	88	68
KOLN ATLANTIC	99	
KOPER EXPRESS	50	
KURE MARU	33	
LASH ATLANTICO	13	16
LAUST MAERSK	14	37
LAWRENCE H. GIANELLA	51	62
LERMA	82	
LESLIE LYKES	122	144
LETITIA LYKES	47	74
LIBERTY BELLE	13	
LIBERTY SPIRIT	16	
LIBERTY STAR	35	80
LIBERTY SUN	50	138
LIBERTY VICTORY,MANILA		58
LIBERTY WAVE	8	
LION OF CALIFORNIA	32	47
LIRCAY	104	77
LNG AQUARIUS	27	
LNG CAPRICORN	18	29
LNG LEO	24	103
LNG TAURUS		157
LNG VIRGO	11	173
LONG LINES	2	
LOUISE LYKES	32	66
LT ARGOSY	68	
LUCY OLDENDORFF	71	
LUNA MAERSK	40	140
LURLINE	73	178
M.V. AINO,NORWAY	88	62
M.V. BROOKLYN BRIDGE,P	181	74
M.V. PAC SUN,YANGON-MY	127	
M.V. TRICHORD SUCCESS,	43	51
M.V. TRIGGER	159	72
M/V AMULET,DENMARK	31	68
MAASSLOT	53	
MAASSTROOM	112	
MACKINAC BRIDGE	172	32
MADAME BUTTERFLY	12	
MADISON MAERSK	24	43
MAERSK CONSTELLATION	76	
MAERSK SUN	42	
MAGLEBY MAERSK	51	84
MAJ STEPHEN W PLESS MP		12
MANHATTAN BRIDGE	171	
MANUKAI	38	92
MANULANI	55	109
MARATHA MAJESTY	1	
MARCHEN MAERSK	9	140
MAREN MAERSK	36	100
MARGARET LYKES	36	82
MARGRETHE MAERSK	47	100
MARIE MAERSK	40	50
MARIF	41	29
MARINE PRINCESS		38
MARINE RELIANCE	160	
MARIT MAERSK	50	101
MARJORIE LYKES	15	
MARLIN		165
MASON LYKES	38	48
MATHILDE MAERSK	7	26
MATSONIA	98	186
MAUI	36	144
MAYAGUEZ	115	194
MAYVIEW MAERSK	45	92
MC-KINNEY MAERSK	50	92
MEDALLION	93	100
MELBOURNE HIGHWAY	8	
MELBOURNE STAR	136	
MELVILLE	73	87
MERCANDIAN CONTINENT	26	16
MERCANDIAN SUN II	38	13
MERCHANT PRELUDE	13	
MERCURY ACE	103	
MERIDA	29	
MERKUR PORTUGAL	16	
METTE MAERSK	2	92
MICHIGAN	120	219
MICHIGAN HIGHWAY	3	
MICRONESIAN COMMERCE	32	
MICRONESIAN INDEPENDEN	34	30
MICRONESIAN PRIDE	203	
MING AUTUMN	10	
MING PLEASURE	13	
MING PLENTY	44	
MING PROMINENCE	43	
MING PROPITIOUS		2
MING PROSPERITY	33	50
MITLA	40	42
MOANA PACIFIC	180	181
MOANA WAVE	60	160
MOKU PAHU	16	44
MONTE CERVANTES	46	
MONTERREY	117	55
MORELOS	131	
MORMACSKY	27	31
MORMACSTAR	36	127
MORMACSUN	46	93
MV EVER GLOBE,PANAMA		8
MV JALAVIHAR,INDIA	3	47
MV JUBILANT,LIBERIA	3	30
MV YOUNG SATO,PANAMA	19	28
MYSTIC	84	
NAPIER STAR	32	
NARA	77	
NATAL	5	18
NATIONAL DIGNITY	37	51
NATIONAL HONOR	32	96

	RADIO	MAIL
NATIONAL PRIDE	22	37
NCC ARAR	12	16
NECHES	5	
NEDLLOYD BAHRAIN	1	
NEDLLOYD CLARENCE	1	
NEDLLOYD HOLLAND	60	107
NEDLLOYD HUDSON	85	116
NEDLLOYD MAAS	19	
NEDLLOYD MANILA	106	
NEDLLOYD MARSEILLS	80	
NEDLLOYD ROTTERDAM	129	
NEDLLOYD TOKYO	30	
NEDLLOYD VAN CLOON	84	
NEDLLOYD VAN DIEMEN	93	
NEDLLOYD VAN LINSCHOTE	111	
NEDLLOYD VAN NOORT	69	
NEPTUNE ACE	12	
NEPTUNE AMBER	9	
NEPTUNE AZURITE	31	
NEPTUNE CORAL	29	
NEPTUNE CRYSTAL	38	
NEPTUNE DIAMOND	161	
NEPTUNE GARNET	46	
NEPTUNE JADE	41	
NEPTUNE PEARL	38	
NEW CONDESA	66	
NEW HORIZON	83	48
NEW YORK SENATOR	19	
NEWARK BAY	52	115
NIPPON HIGHWAY	10	
NOAA DAVID STARR JORDA	136	136
NOAA SHIP ALBATROSS IV	285	387
NOAA SHIP CHAPMAN	359	373
NOAA SHIP DISCOVERER O	193	192
NOAA SHIP FERREL	31	
NOAA SHIP M. BALDRIDGE	277	
NOAA SHIP MILLER FREEM	479	598
NOAA SHIP OREGON II	118	184
NOAA SHIP RAINIER	55	
NOAA SHIP SURVEYOR	156	81
NOAA SHIP T. CROMWELL	5	155
NOAA SHIP WHITING	54	
NORGAS VICTORY	70	
NOSAC EXPRESS	62	84
NOSAC RANGER	68	50
NOSAC TAKAYAMA	1	
NUEVO SAN JUAN	12	
NURNBERG ATLANTIC	78	
NYK STARLIGHT	78	
OAXACA	148	96
OBO ENGIN	46	
OCEAN ASPIRATION	18	16
OCEAN CHEER	71	
OCEAN CONQUEROR	12	42
OCEAN EXPLORER	5	60
OCEAN HIGHWAY	45	
OCEAN SEL	1	
OLEANDER	80	42
OLGA TOPIC		46
OLIVE ACE	121	112
OMI CHARGER	19	23
OMI MISSOURI	114	147
OMI WABASH	16	49
OOCL BLOSSOM	118	
OOCL BRAVERY	59	
OOCL EDUCATOR	55	
OOCL ENVOY	95	81
OOCL EXECUTIVE	62	47
OOCL EXPLORER	114	149
OOCL EXPORTER	63	
OOCL FAIR	122	82
OOCL FAITH	71	
OOCL FIDELITY	65	72
OOCL FORTUNE	88	
OOCL FREEDOM	143	
OOCL FRIENDSHIP	12	
ORANGE BLOSSOM	78	136
ORANGE STAR	51	80
ORCHID	25	47
OREGON RAINBOW II	73	115
OREGON STAR	152	
ORION HIGHWAY	92	164
OVERSEAS BOSTON	26	52
OVERSEAS CHICAGO	30	
OVERSEAS HARRIET	38	
OVERSEAS JOYCE	72	160
OVERSEAS JUNEAU		145
OVERSEAS MARILYN	58	
OVERSEAS NEW ORLEANS	31	47
OVERSEAS NEW YORK	58	84
OVERSEAS OHIO	11	73
PACASIA	40	28
PACDUCHESS	22	
PACDUKE	25	
PACIFIC EMERALD	85	
PACIFIC PRINCESS	123	
PACKING	43	
PACMERCHANT	68	48
PACNOBLE	7	
PACOCEAN	25	
PACPRINCE	27	6
PACPRINCESS	90	
PACQUEEN	33	
PACSEA	34	
PACSTAR	3	
PACTRADER	20	
PAPAGO	49	
PAPYRUS	165	
PATRIOT	88	
PATRIOT STATE	82	156
PAUL BUCK	3	74
PAUL R. TREGURTHA	25	
PC EXPLORER	2	30
PECOS	47	51
PEGGY ANN,USA	6	14
PEGGY DOW	50	
PEMBINA	36	
PETER W. ANDERSON	44	43
PETROBULK PROGRESS	116	
PFC DEWAYNE T. WILLIAM	7	
PFC EUGENE A. OBREGON	12	8
PFC JAMES ANDERSON JR	53	54
PFC WILLIAM B. BAUGH	68	38
PHAROS	65	
PHILIP R. CLARKE	1	
POLAR ALASKA	26	104
POLYNESIA	202	217
POTOMAC TRADER	22	13
PRESIDENT ADAMS	101	126
PRESIDENT ARTHUR		38
PRESIDENT BUCHANAN	32	28
PRESIDENT EISENHOWER	175	241
PRESIDENT F. ROOSEVELT	111	214
PRESIDENT GARFIELD	12	
PRESIDENT GRANT	68	127
PRESIDENT HARDING	64	
PRESIDENT HARRISON	114	
PRESIDENT HOOVER	53	76
PRESIDENT JACKSON	175	134
PRESIDENT JEFFERSON	46	93
PRESIDENT KENNEDY	115	126
PRESIDENT LINCOLN	125	180
PRESIDENT MONROE	141	205
PRESIDENT POLK	196	222
PRESIDENT TRUMAN	26	45
PRESIDENT TYLER	44	127
PRESIDENT WASHINGTON	275	20
PRIDE OF BALTIMORE	4	
PRINCE OF OCEAN	117	228
PRINCE OF TOKYO	109	226
PRINCE OF TOKYO 2	33	43
PRINCE WILLIAM SOUND	28	169
PRINSENGRACHT	42	
PRODUCT SPLENDOR	62	
PROSPERO	9	114
PVT FRANKLIN J. PHILLI	31	
PYTCHLEY	201	
QUEEN ELIZABETH 2	100	
QUEENSLAND STAR	120	
R. HAL DEAN	75	
R.J. PFEIFFER	122	154
RAINBOW HOPE	3	
RALEIGH BAY	58	136
RANGER	26	
RANI PADMINI	25	
RECIFE	255	
REFORM	41	
RESOLUTE	60	127
RICHARD G MATTIESEN	16	
ROBERT E. LEE	35	48
ROSETTA	77	88
ROSINA TOPIC	1	
ROTTERDAM	56	
ROVER	106	216
ROWANBANK	90	
ROYAL PRINCESS	164	
RUBIN DOGA	47	
RUBIN OCEAN	78	
RUTH LYKES	52	
S.T. CRAPO	21	
S/S BLUE RIDGE	3	4
SALINA CRUZ PILOTS	277	
SALINAS	30	
SAM HOUSTON	41	26
SAMUEL H. ARMACOST	54	73
SAMUEL L. COBB	92	87
SAN JUAN	112	
SAN MARCOS	39	129
SAN MARTIN	96	
SAN PEDRO	46	
SANGAY	109	
SANGHA	14	
SANKO LILY	32	20
SANKO PIONEER	34	
SANKO PRELUDE	8	11
SANTA BARBARA	40	
SANTOS	32	
SAPAI	2	
SATURN DIAMOND	48	
SAVANNAH	1	
SCARAB	46	
SEA BELLS	15	171
SEA FAN	63	34
SEA FORTUNE	16	96
SEA FOX	48	54
SEA LIGHT	15	34
SEA LION	295	127
SEA MERCHANT	298	48
SEA TRADE	2	
SEA WEALTH	8	52
SEA WOLF	130	71
SEALAND ACHIEVER	166	120
SEALAND ANCHORAGE	88	191
SEALAND ATLANTIC	74	147
SEALAND CHALLENGER	35	72
SEALAND CONSUMER	102	160
SEALAND CRUSADER	99	114
SEALAND DEFENDER	105	
SEALAND DEVELOPER	51	97
SEALAND DISCOVERY	32	44
SEALAND ENDURANCE	54	106
SEALAND ENTERPRISE	244	251
SEALAND EXPEDITION	38	
SEALAND EXPLORER	89	96
SEALAND EXPRESS	56	74
SEALAND HAWAII	210	78
SEALAND INDEPENDENCE	84	166
SEALAND INNOVATOR	92	72
SEALAND INTEGRITY	167	231
SEALAND KODIAK	39	37
SEALAND LIBERATOR	61	125
SEALAND MARINER	16	
SEALAND NAVIGATOR	240	258
SEALAND PACIFIC	178	196
SEALAND PATRIOT	57	52
SEALAND PERFORMANCE	91	159
SEALAND PRODUCER	95	240
SEALAND QUALITY	61	126
SEALAND RELIANCE	125	227
SEALAND SPIRIT	65	66
SEALAND TACOMA	58	114
SEALAND TRADER	160	173
SEALAND VALUE	58	55
SEALAND VOYAGER	38	106
SEAWARD BAY	29	43
SEDCO/BP 471	265	317

	RADIO	MAIL
SEMINOLE		124
SENATOR	89	76
SGT WILLIAM A BUTTON	12	
SGT. METEJ KOCAK	5	6
SHELDON LYKES	89	58
SHELLY BAY	40	103
SHIRAOI MARU	128	54
SHOSHONE SPIRIT	6	
SIDNEY STAR	131	
SINCERE SUCCESS	14	22
SKANDERBORG	53	66
SKAUBRYN	147	
SKAUGRAN	122	138
SKAUKAR,LIBERIA	36	65
SOLAR WING	116	200
SONORA	76	153
SOUND CRUZ,MEXICO		88
SOUTHLAND STAR	193	
SPRING BEAR	122	
ST BLAIZE	43	
STAFFORDSHIRE	99	
STAR ALABAMA	24	
STAR AMERICA	51	53
STAR DRIVANGER	89	
STAR EAGLE	88	106
STAR EVVIVA	32	
STAR FLORIDA	105	127
STAR FRASER	56	
STAR FUJI	41	
STAR GEIRANGER		24
STAR GRAN	72	195
STAR GRINDANGER	4	
STAR MERCHANT	14	
STAR WESTCHESTER	2	
STAR WILMINGTON	26	22
STELLA LYKES	31	120
STENA TRANSFER,BERMUDA	36	36
STEWART J. CORT	49	58
STRIDER ISIS	54	24
STRIDER JUNO	164	
STRONG AMERICAN,USA		94
SUE LYKES	48	97
SUGAR ISLANDER	2	33
SUNBELT DIXIE	156	148
SUNNY SUPERIOR	69	
SUNRISE RUBY	105	166
SYNNOVE KNUSTEN	24	2
TABASCO	42	
TAI CHUNG	67	67
TAI HE	114	
TAI SHING	17	31
TAMPA	33	
TAMPA BAY	41	91
TARKWA	6	
TEXAS SUN	10	18
TEXAS TRADER	16	
THOMAS G. THOMPSON	2	7
THOMPSON LYKES	41	112
THOMPSON PASS	7	57
TILLIE LYKES	50	
TOKYO HIGHWAY	17	
TOLUCA	142	53
TONCI TOPIC	2	
TONSINA	46	176
TORM FREYA	132	90
TOWER BRIDGE	77	
TRANSWORLD BRIDGE	152	62
TROLL FOREST	121	
TROPICAL BEAUTY		209
TROPICALE	6	
TSL BOLD	251	345
TULSIDAS	31	
TYSON LYKES	35	16
UCHOA	135	277
ULLSWATER	227	
ULTRAMAX	25	
ULTRASEA	12	24
UNAMONTE	4	
UNIVERSE	38	
USCGC ACACIA (WLB406)	7	10
USCGC ACTIVE WMEC 618	33	
USCGC ACUSHNET WMEC 16	6	
USCGC BASSWOOD (WLB 38	1	
USCGC BEAR (WEMC 901)	58	
USCGC BISCAYNE BAY	3	18
USCGC BRAMBLE (WLB 392	1	
USCGC BUTTONWOOD WLB 3	5	
USCGC CAMPBELL	62	
USCGC CHASE (WHEC 718)	48	
USCGC CITRUS (WMEC 300	14	
USCGC DEPENDABLE	39	
USCGC DILIGENCE WMEC 6		10
USCGC DURABLE (WMEC 62	9	
USCGC ESCANABA	2	
USCGC FIREBUSH WLB 393	5	
USCGC FORWARD	90	
USCGC GALLATIN	4	
USCGC GALVESTON ISLAND	1	
USCGC HARRIET LANE	12	
USCGC IRONWOOD (WLB 29	34	
USCGC JARVIS (WHEC 725	103	
USCGC LAUREL (WLB 291)	14	
USCGC MACKINAW	54	87
USCGC MELLON (WHEC 717	88	114
USCGC MIDGETT (WHEC 72	45	
USCGC MOHAWK WMEC 913	77	
USCGC NORTHLAND WMEC 9	125	140
USCGC PLANETREE	3	
USCGC POLAR SEA__(WAGB	79	
USCGC POLAR STAR (WAGB	110	131
USCGC RELIANCE WMEC 61	6	
USCGC RESOLUTE WMEC 62	61	
USCGC RUSH	166	
USCGC SASSAFRAS	62	
USCGC SEDGE (WLB 402)	53	
USCGC SENECA	78	93
USCGC SPENCER		55
USCGC STORIS (WMEC 38)	135	
USCGC SUNDEW (WLB 404)	2	9
USCGC SWEETBRIER WLB 4	10	
USCGC TAHOMA	21	
USCGC TAMAROA (WMEC 16	44	
USCGC TAMPA WMEC 902	87	27
USCGC VIGILANT WMEC 61	23	
USCGC YOCONA (WMEC 168	8	
USNS ABLE	54	
USNS ALGOL	57	
USNS BARTLETT(T-AGOR 1	35	
USNS BELLATRIX	46	
USNS CAPELLA	25	57
USNS DENEBOLA	43	
USNS GUS W. DARNELL	4	
USNS HARKNESS (T-AGS 3	28	
USNS HENRY J. KAISER		62
USNS JOHN MCDONNELL (T		164
USNS KANAWHA T-AO 196		53
USNS MERCURY	49	
USNS MOHAWK (T-ATF 170	96	
USNS POTOMAC	6	
USNS POWHATAN TATF 166	19	
USNS REDSTONE	56	61
USNS REGULUS	4	
USNS SEALIFT ANTARCTIC	2	96
USNS SEALIFT ARABIAN S	48	
USNS SEALIFT ARCTIC	27	
USNS SEALIFT ATLANTIC	62	80
USNS SEALIFT CHINA SEA	65	
USNS SEALIFT MEDITERRA	67	84
USNS SILAS BENT T-AGS	57	
USNS SIOUX		102
USNS VANGUARD TAG 194	80	
USNS WALTER S. DIEHL	34	
USNS WILKES T-AGS-33	46	36
USNSCATAWBA T-AFT-168,		74
VAN TRADER	15	
VERA ACORDE	2	
VINE	135	
VIRGINIA	83	341
VISHVA VIKRAM	4	
VIVA	88	156
WASHINGTON HIGHWAY	4	
WASHINGTON RAINBOW #2	56	114
WECOMA	223	265
WELLINGTON STAR	126	
WEST MOOR	94	
WESTERN FUTURE	52	54
WESTWARD	74	106
WESTWARD VENTURE	38	71
WESTWOOD ANETTE	79	121
WESTWOOD BELINDA	35	
WESTWOOD CLEO	79	86
WESTWOOD JAGO	115	45
WESTWOOD MARIANNE	41	121
WILFRED SYKES	12	15
WILLIAM E. MUSSMAN	46	75
WOLVERINE	1	
WORLD WING #2	103	214
YACU WAYO	10	
YANKEE CLIPPER	42	
YOUNG SPROUT	73	86
ZETLAND	269	
ZIM AMERICA	47	
ZIM CANADA	74	
ZIM HOUSTON	34	
ZIM IBERIA	23	
ZIM KEELUNG	59	
ZIM MARSEILLES	11	
ZIM MIAMI	69	
ZIM SAVANNAH	11	

SUMMARY: GRAND TOTAL VIA RADIO 52259

GRAND TOTAL VIA MAIL 41499

TOTAL UNIQUE OBS 73237

TOTAL DUPLICATES 20521 (28.0%)

UNIQUE RADIO OBS.31738 (43.3%)

UNIQUE MAIL OBS. 20978 (28.6%)

January, February, and March 1993

CALL SIGN	TOTAL	BATHY	TESAC	SHIP NAME	CALL SIGN	TOTAL	BATHY	TESAC	SHIP NAME
BOAB	62	62	0	TAI HE	JCCX	58	58	0	CHOFU MARU
CBVM	11	11	0	VINA DEL MAR	JDRD	62	62	0	SHOYO MARU
CGDV	230	50	180	W. TEMPLEMAN	JDWX	75	75	0	KOFU MARU
CG2676	4	0	4	SHAMOOK	JFDG	48	48	0	SHUMPU MARU
CG2683	3	3	0	ALFRED NEEDLER	JFPQ	153	153	0	KASHIMASAN MARU
CWBP	12	12	0	***	JGZK	86	86	0	RYOFU MARU
CYWK	34	0	34	ENDEAVOR	JITV	38	38	0	WELLINGTON MARU
CZDO	2	2	0	QUEST	JIVB	39	39	0	SEIFU MARU
C6HL8	28	28	0	COLUMBIA STAR	JKCF	16	16	0	GEORGE WASHINGTON BRID
C6IO5	69	69	0	NATHALIE DELMAS	JNZL	105	105	0	KAIYO MARU
C6JY6	196	196	0	MELBOURNE STAR	J8FN	6	6	0	VIDAL
C6JZ2	63	63	0	AMERICA STAR	KGJB	3	3	0	SEALAND DEFENDER
DAKE	167	167	0	KOELN ATLANTIC	KIRH	52	52	0	SEALAND TRADER
DBBH	102	102	0	METEOR	KNFG	81	81	0	SEA WOLF
DBFP	23	23	0	WALTHER HERWIG	KNVF	1	1	0	***
DBLK	191	191	0	POLARSTERN	KRGB	74	74	0	SEALAND ENTERPRISE
DD8436	44	44	0	FEHMARNBELT	LADB2	33	33	0	SKAUGRAN
DGLM	101	101	0	MONTE ROSA	LAJV4	44	44	0	SKAUBRYN
DGVK	79	79	0	COLUMBUS VICTORIA	LOAI	69	69	0	ALMIRANTE IRIZAR
DGZV	78	78	0	COLUMBUS VIRGINIA	NABL	1	1	0	***
DHCW	33	33	0	COLUMBUS WELLINGTON	NAVOCE	12	12	0	U.S. NAVAL OCEANOGRAPHIC
DIDA	44	44	0	ARIANA	NBTM	6	6	0	POLAR STAR
DLEZ	38	38	0	YANKEE CLIPPER	NFBS	1	1	0	STUMP
D5BC	66	66	0	SEDCO BP/471	NHTM	3	3	0	***
D5NE	99	99	0	MT CABRITE	NICB	3	3	0	***
D5NZ	81	81	0	POLYNESIA	NIDK	10	10	0	ICEPAT GROTON CT
ELAX2	57	57	0	MICRONESIAN PRIDE	NIKA	1	1	0	SEALIFT ATLANTIC
ELBX3	32	32	0	PACKING	NKID	1	1	0	KIDD
ELEH4	37	37	0	C R POINTE NOIRE	NNJB	47	47	0	***
ELHL6	77	77	0	COLUMBUS OHIO	NRCD	2	2	0	JARRETT
ELIL9	82	82	0	NAVIGATOR	NRUO	3	3	0	POLAR SEA
ELIS8	72	72	0	MARINER	NUKJ	7	7	0	STERETT
ELOF7	7	7	0	LONGAVI	NZSK	1213	1213	0	E.KANE
ERES	26	25	1	VICTOR BUGAEN	N900AM	116	116	0	***
ERET	1	1	0	GEORGE OUSHAKOV	OWUO6	107	107	0	MOANA PACIFIC
FGPT	1	1	0	***	PGEC	52	52	0	NEDLLOYD VAN NOORT
FHZI	69	69	0	L'ASTROLABE	PJJU	25	25	0	OLEANDER
FNCM	50	50	0	***	RV6	80	80	0	***
FNCZ	50	50	0	DELMAS SURCOUF	SCOU	1	1	0	TV 243
FNDK	37	37	0	PATRICIA DELMAS	SCPH	1	1	0	TV 257
FNGB	96	96	0	MARION DUFRESNE	SCPL	1	1	0	***
FNGS	93	93	0	LA FAYETTE	SEXN	1	1	0	TV 227
FNOM	9	9	0	RENOIR	SEXQ	1	1	0	TV 278
FNQC	38	38	0	VILLE DE ROUEN	SHIP	453	453	0	***
FNQM	59	59	0	SUZANNE DELMAS	SHPF	1	1	0	TV 281
FNXW	17	17	0	SAINT ROCH	SJIB	1	1	0	TV 282
FNZO	5	5	0	RABELAIS	SKVP	3	3	0	TV 284
FNZP	17	17	0	RACINE	SLDN	2	2	0	TV 10
FNZQ	57	57	0	RIMBAUD	S6FK	111	111	0	SWAN REEFER
FPYO	7	7	0	CAP SAINT PAUL	TFEA	12	12	0	BJARNI SAEMUNDSSON
GACA	67	67	0	CUMULUS	TFJA	5	5	0	ARNI FRIDRIKSSON
GLNE	101	101	0	DISCOVERY	TFUD	8	8	0	BRUARFOSS
GQEK	49	49	0	FORTHBANK	TFVD	7	7	0	***
GXRH	30	30	0	ENDURANCE	TUMG	2	2	0	GRAND BASSAM
GYRW	42	42	0	ENCOUNTER BAY	TWR3	2	2	0	***
GYSA	33	33	0	FLINDERS BAY	UINF	6	6	0	VLADIMIR PARSHIN
GYSE	29	29	0	NEDLLOYD TASMAN	UJFO	207	207	0	MULTANOVSKIY PROF
HPAN	18	18	0	MICRONESIAN COMM.	VCBT	3	3	0	CAPE ROGER
HPEW	101	101	0	PACIFIC ISLANDER	VJBQ	28	28	0	ANRO AUSTRALIA
H9BQ	20	20	0	MICRONESIAN INDEP.	VJDI	24	24	0	IRON NEWCASTLE
JBOA	8	8	0	KEIFU MARU	VJDP	73	73	0	IRON PACIFIC

Bathy–Tesac Data at NMC

January, February, and March 1993

CALL SIGN	TOTAL	BATHY	TESAC	SHIP NAME
VKCK	1	1	0	STUART
VKCN	90	90	0	CANBERRA
VKCV	135	135	0	DERWENT
VKLC	28	28	0	BRISBANE
VKLP	75	75	0	HMAS MELBOURNE
VKMK	46	46	0	SWAN
VKML	35	35	0	SYDNEY
VKPT	8	8	0	PERTH
VLNB	97	97	0	TORRENS
VSBI3	54	54	0	BIBI
VXN8	533	533	0	AIRCRAFT
WCGN	14	14	0	CHEVRON CALIFORNIA
WECB	24	24	0	MELVILLE
WPGK	16	16	0	SEALAND NAVIGATOR
WPKD	75	75	0	SEALAND ACHIEVER
WRBA	3	3	0	PACMISRANFAC HAWAREA
WRBB	5	5	0	PACIFIC MISSLE RANGE
WSRL	62	62	0	SEALAND PACIFIC
WTDM	81	80	1	MILLER FREEMAN
WTDO	28	20	8	OREGON II
WTEA	17	17	0	DISCOVERER
WTER	4	4	0	MALCOLM BALDRIGE
WTES	55	55	0	SURVEYOR
WXBR	36	36	0	CHEVRON MISSISSIPPI
YDLR	75	75	0	BOGASARI LIMA
Y3CH	7	0	7	PROF. ALBRECHT PENK
Y3CW	6	0	6	A. V. HUMBOLDT
ZCAQ9	188	188	0	WEST MOOR
ZCKU	9	9	0	STAR MAGNATE
ZDAZ6	88	88	0	EXPLORER
ZDBE9	36	36	0	VOYAGER
3BBA	2	2	0	MAURITIUS
3EAW7	25	25	0	ANDINO
3EET4	34	34	0	SEAS EIFFEL
3EGR6	76	76	0	RECIFE
3EHT6	28	28	0	KARINA BONITA
7JDU	173	173	0	NATSUSHIMA
7JOB	10	10	0	CALIFORNIA CERES
7JWN	24	24	0	TAKUYO
7KDD	21	21	0	YOKO MARU
9VBZ	1	1	0	MAHSURI
9VUU	3	3	0	ANRO ASIA
9VVB	64	64	0	GOLDENSARI INDAH
9VWM	16	16	0	MANDAMA
21002	619	619	0	BUOY
21004	694	694	0	BUOY
22001	696	696	0	BUOY
32315	91	91	0	BUOY
32316	64	64	0	BUOY
32317	55	55	0	BUOY
32318	57	57	0	BUOY
32319	149	149	0	BUOY
32320	67	67	0	BUOY
32321	62	62	0	BUOY
32322	37	37	0	BUOY
43001	65	65	0	BUOY
51006	60	60	0	BUOY
51007	107	107	0	BUOY
51009	57	57	0	BUOY
51010	64	64	0	BUOY
51014	58	58	0	BUOY
51015	61	61	0	BUOY
51017	63	63	0	BUOY
51018	65	65	0	BUOY
51019	65	65	0	BUOY
51020	56	56	0	BUOY
51021	41	41	0	BUOY
51022	34	34	0	BUOY
51301	164	164	0	BUOY
51302	59	59	0	BUOY
51303	56	56	0	BUOY
51304	59	59	0	BUOY
51305	61	61	0	BUOY
51306	45	45	0	BUOY
51307	16	16	0	BUOY
51308	56	56	0	BUOY
51309	60	60	0	BUOY
51310	59	59	0	BUOY
52001	55	55	0	BUOY
52002	51	51	0	BUOY
52003	54	54	0	BUOY
52006	56	56	0	BUOY
52007	57	57	0	BUOY
52008	17	17	0	BUOY
52010	58	58	0	BUOY
52011	50	50	0	BUOY
52012	42	42	0	BUOY
52301	40	40	0	BUOY
52302	45	45	0	BUOY
52303	63	63	0	BUOY
52304	47	47	0	BUOY
52305	28	28	0	BUOY
52307	56	56	0	BUOY
52308	57	57	0	BUOY

TOTAL BATHYS RECEIVED	14005
TOTAL TESACS RECEIVED	241
TOTAL REPORTS RECEIVED	14246

January, February, and March 1993

Wave observations are taken each hour during a 20–minute averaging period, with a sample taken every 0.67 seconds. The significant wave height is defined as the average height of the highest one–third of the waves during the average period each hour. The maximum significant wave height is the highest of those values for that month. At most stations, air temperature, water temperature, wind speed and direction are sampled once per second during an 8.0–minute averaging period each hour (moored buoys) and a 2.0–minute averaging period for fixed stations (C–MAN). Contact NDBC Data Systems Division, Bldg 1100, SSC, Mississippi 39529 or phone (601) 688–2838 for more details.

BUOY	LAT	LONG	OBS	MEAN AIR TP (C)	MEAN SEA TP (C)	MEAN SIG WAVE HT (M)	MAX SIG WAVE HT (M)	MAX SIG WAVE HT (DA/HR)	SCALAR MEAN WIND SPEED (KNOTS)	PREV WIND (DIR)	MAX WIND (KTS)	MAX WIND (DA/HR)	MEAN PRESS (MB)
January													
32302	18.0S	085.1W	0731	22.0	22.1	1.5	2.4	26/01	9.2	SE	18.3	31/17	1014.2
41002	32.3N	075.2W	0728	19.1	21.6	2.5	7.3	27/00	15.6	S	36.5	26/20	1020.4
41004	32.5N	079.1W	0735	16.7	21.1				15.8	NE	35.6	26/19	1021.5
41006	29.3N	077.4W	0734	21.9	23.8	2.3	6.9	27/06	14.4	S	33.8	27/16	1019.3
41009	28.5N	080.2W	1465	21.1	22.4	1.8	6.1	27/10	12.0	S	35.0	27/02	1019.2
41010	28.9N	078.5W	1460	22.0	23.6	2.2	6.8	27/10	13.8	S	33.8	27/15	1019.7
41016	24.6N	076.5W	0739	23.9	25.2	0.8	2.0	26/18	15.0	E	29.7	27/19	1018.3
42001	25.9N	089.7W	0735	22.1	23.2	1.3	3.3	25/15	11.9	SE	26.8	26/19	1019.0
42002	25.9N	093.6W	0736	21.6	23.1	1.4	4.3	24/21	12.8	NE	28.2	24/20	1018.3
42003	25.9N	085.9W	0736	23.5	26.6	1.4	3.5	04/05	14.4	E	34.8	26/21	1018.2
42007	30.1N	088.8W	0728	14.1	15.7				12.1	N	30.1	25/05	1020.0
42019	27.9N	095.0W	0739	18.6	21.8	1.5	4.4	24/15	13.9	NE	34.4	24/12	1018.9
42020	27.0N	096.5W	0735	18.7	20.8	1.5	5.0	24/13	12.1	N	33.8	24/10	1018.8
44005	42.6N	068.6W	0732	0.9	5.4	2.2	5.2	14/13	16.3	NW	34.8	30/18	1019.4
44007	43.5N	070.1W	0265	-1.9	4.9	1.1	3.3	28/11	15.2	N	31.7	29/23	1017.7
44013	42.4N	070.8W	0733	-0.1	3.9	0.8	3.8	14/10	14.6	W	38.5	29/22	1020.9
44014	36.6N	074.8W	0740	8.8	10.4	1.7	5.2	10/04	14.6	N	30.5	09/18	1022.0
44025	40.3N	073.2W	0739	4.4	6.2	1.4	3.5	09/22	14.9	NW	29.1	30/00	1021.9
46001	56.3N	148.2W	0735	2.0	4.5	3.1	9.1	17/16	15.8	W	34.4	02/21	1010.1
46002	42.5N	130.3W	0728	9.6	11.5	3.2	7.2	19/22	16.2	N	39.2	20/07	1013.5
46003	51.9N	155.9W	0735	2.6	4.2	3.1	8.2	17/04	16.1	S	40.8	17/04	1011.2
46005	46.1N	131.0W	0737	7.9	9.7	3.4	7.9	19/18	16.3	NE	33.6	19/15	1012.6
46006	40.9N	137.5W	0733	10.7	12.8	3.4	7.5	19/09	17.3	N	33.0	20/13	1015.3
46012	37.4N	122.7W	0729	11.7	12.9	2.2	4.9	13/02	12.5	N	29.9	13/02	1014.6
46013	38.2N	123.3W	0732	10.6	12.2	2.4	6.0	20/16	13.6	E	35.6	12/23	1014.1
46014	39.2N	124.0W	0688	10.1	11.8	2.3	5.9	20/17	10.8	E	28.4	19/23	1013.9
46022	40.8N	124.5W	0724	9.0	10.8	2.4	7.0	22/07	10.0	SE	35.6	22/03	1014.4
46023	34.3N	120.7W	0732	13.3	13.9	2.2	5.2	14/14	11.6	NW	33.0	12/20	1014.9
46025	33.8N	119.1W	0732	13.7	14.6	1.3	4.2	14/18	9.3	E	28.0	06/11	1015.3
46026	37.8N	122.7W	0736	10.2	11.5	1.7	4.1	22/13	13.6	NE	34.0	30/07	1015.0
46027	41.8N	124.4W	0720	8.5	10.1	2.3	6.4	20/11					1014.0
46028	35.8N	121.9W	0734	12.7		2.1	3.5	07/01	11.3	NW	34.0	14/06	1014.9
46029	46.2N	124.2W	0737	5.9	9.2	2.3	7.5	20/15	15.0	E	39.7	20/14	1014.3
46030	40.4N	124.5W	0734	9.4	11.2	1.6	6.3	22/06	11.0	N	35.4	20/00	1014.1
46035	57.0N	177.7W	0731	-1.3	2.5	3.5	11.3	07/06	17.8	E	41.6	07/05	1006.0
46041	47.4N	124.5W	0721	5.2	7.7	2.1	6.8	20/19	10.9	SE	29.7	19/13	1013.9
46042	36.8N	122.4W	0725	11.7		2.3	5.3	14/14	12.5	E	33.4	12/23	1015.1
46045	33.8N	118.5W	0731	13.4	14.5	1.0	2.9	14/18	7.7	E	24.7	08/10	1014.9
46047	32.7N	119.6W	0741	14.3	14.9	2.1	4.5	18/19	12.3	NW	33.0	19/01	1015.8
46048	32.9N	117.9W	0732	14.4	15.3	1.3	3.1	06/14	9.9	NW	30.7	13/00	1015.3
46050	44.6N	124.5W	0728	7.4	9.9	2.3	6.8	20/13	13.0	E	38.1	20/12	1014.4
46051	34.5N	120.7W	0729	13.3	14.1	2.1	5.0	14/14	11.2	NW	37.5	12/19	1015.3
51001	23.4N	162.3W	0737	21.7	23.9	3.0	6.8	06/03	13.6	NW	29.7	05/15	1014.2
51002	17.2N	157.8W	0211	24.5	25.5	2.5	4.8	06/14	14.4	E	23.0	16/17	1014.1
51003	19.3N	160.8W	0736	23.5	25.3	2.7	6.0	07/04	12.7	E	28.2	05/13	1012.9
51004	17.4N	152.5W	0737	23.8	24.7	2.4	3.9	06/14	13.3	E	24.3	06/07	1012.5
51026	21.4N	157.0W	0358	22.7	23.4	2.0	3.5	30/04	10.6	E	24.3	29/22	1014.9
52009	13.7N	144.7E	0380		25.8	2.2	3.5	08/04	14.8	E	22.0	07/09	1011.8
91222	18.1N	145.8E	0685	25.0					7.2	E	15.8	06/23	1014.4
91251	11.4N	162.4E	0731	25.9					19.2	NE	28.7	16/03	1011.8
91328	8.6N	149.7E	0737	26.9					11.7	NE	22.2	27/17	1009.6
91343	7.6N	155.2E	0734	26.9					15.6	NE	26.6	24/21	1010.6
91352	6.2N	160.7E	0737	27.1					13.4	NE	23.1	26/02	1009.5
91355	5.4N	163.0E	0734	27.0					10.3	NE	24.6	01/16	1008.4
91377	6.1N	172.1E	0734	26.8									1008.1
ABAN6	44.3N	075.9W	0708	-4.0	0.7				4.8	S	22.7	13/16	1021.8
ALSN6	40.5N	073.8W	0734	3.0		1.0	2.5	13/23	16.8	NW	38.9	25/04	1022.7
CARO3	43.3N	124.4W	0734	6.9					9.8	SE	45.9	20/14	1013.3
CHLV2	36.9N	075.7W	0736	6.9	7.2	1.3	4.0	10/02	16.4	N	33.6	24/23	1022.8
CLKN7	34.6N	076.5W	0734	10.3					13.6	NE	35.7	26/13	1022.3
CSBF1	29.7N	085.4W	0732	15.4					6.0	E	30.9	21/18	1019.9
DISW3	47.1N	090.7W	0732	-6.3					14.1	SW	35.5	30/02	1021.0

BUOY	LAT	LONG	OBS	MEAN AIR TP (C)	MEAN SEA TP (C)	MEAN SIG WAVE HT (M)	MAX SIG WAVE HT (M)	MAX SIG WAVE HT (DA/HR)	SCALAR MEAN WIND SPEED (KNOTS)	PREV WIND (DIR)	MAX WIND (KTS)	MAX WIND (DA HR)	MEAN PRESS (MB)
DPIA1	30.3N	088.1W	0729	13.5	13.9				12.4	N	33.4	25 04	1020.0
DRYF1	24.6N	082.9W	0740	23.3	24.5				12.8	E	28.1	27 05	1018.2
DSLN7	35.2N	075.3W	0731	11.6	14.6	2.0	4.6	10 09	19.8	N	44.4	05 14	1021.8
FBIS1	32.7N	079.9W	0733	11.6					9.9	NE	26.2	02 17	1021.7
FFIA2	57.3N	133.6W	0716	0.3					15.0	N	46.3	29 22	1011.3
FPSN7	33.5N	077.6W	0733	14.9	19.1				19.2	N	45.6	26 16	1021.0
FWYF1	25.6N	080.1W	0734	23.3	24.7								1018.7
GDIL1	29.3N	090.0W	0729	15.0	16.2				10.9	NE	29.4	25 04	1019.6
GLLN6	43.9N	076.5W	0734	-3.2					16.4	W	39.6	30 07	1021.2
IOSN3	43.0N	070.6W	0733	-1.3					15.3	W	35.6	22 18	1020.7
LONF1	24.9N	080.9W	0739	22.9	23.4				11.4	NE	28.6	09 11	1018.3
MDRM1	44.0N	068.1W	0728	-2.2					18.2	NW	43.0	25 06	1019.3
MISM1	43.8N	068.9W	0733	-2.1					17.8	NW	44.8	25 10	1020.1
MLRF1	25.0N	080.4W	0734	23.5	25.1				14.9	E	30.4	03 18	1017.9
NWPO3	44.6N	124.1W	0736	5.2					11.2	E	42.9	20 12	1014.0
PILM4	48.2N	088.4W	0734	-7.4					16.0	NW	37.3	31 07	1020.0
PTAC1	39.0N	123.7W	0738	9.0					9.5	SE	30.2	22 05	1015.0
PTAT2	27.8N	097.1W	0731	13.5	15.3				10.6	N	34.0	24 11	1019.3
PTGC1	34.6N	120.7W	0735	12.9					11.9	N	44.0	12 20	1015.0
ROAM4	47.9N	089.3W	0735	-7.2					16.1	NW	38.4	16 06	1020.6
SANF1	24.5N	081.9W	0734	23.3	24.9				14.1	NE	31.5	27 16	1017.8
SAUF1	29.9N	081.3W	0733	15.7					10.1	N	38.3	26 22	1020.6
SBIO1	41.6N	082.8W	0734	-0.8					13.9	SW	36.1	31 08	1021.2
SGNW3	43.8N	087.7W	0735	-4.0	0.5				12.8	W	32.7	26 15	1021.1
SISW1	48.3N	122.9W	0732	3.5					11.1	NE	38.7	20 17	1015.8
SMKF1	24.6N	081.1W	0735	23.5	24.9				15.4	SE	33.9	26 10	1018.1
SPGF1	26.7N	079.0W	0741	22.6	24.8				9.3	E	31.2	27 13	1020.1
SRST2	29.7N	094.1W	0346	11.7					8.5	NE	19.6	10 21	1018.3
STDM4	47.2N	087.2W	0730	-4.9					19.7	NW	44.8	28 22	1018.9
SUPN6	44.5N	075.8W	0742	-5.8	0.7				9.7	SW	26.6	25 07	1020.3
SVLS1	32.0N	080.7W	0734	12.7	12.8	1.1	2.6	26 14	15.5	NE	37.1	26 17	1021.1
TTIW1	48.4N	124.7W	0733	4.3					19.0	E	42.2	13 13	1014.3
VENF1	27.1N	082.5W	0731	19.3	21.1				8.2	NE	31.7	27 10	1019.6
WPOW1	47.7N	122.4W	0734	4.3					9.4	N	43.3	20 18	1014.9
February													
32302	18.0S	085.1W	0663	22.8		1.8	3.3	15 15	10.3	SE	17.3	06 11	1013.5
41002	32.3N	075.2W	0667	16.6	22.3	2.5	5.5	28 03	16.6	NW	33.0	27 00	1016.6
41004	32.5N	079.1W	0671	13.6	20.0				15.1	N	31.3	07 14	1018.5
41006	29.3N	077.4W	0671	19.5	22.7	2.1	4.3	08 18	15.3	NW	30.1	13 04	1016.8
41009	28.5N	080.2W	1335	17.6	20.8	1.3	3.2	03 00	13.5	N	33.2	26 16	1017.6
41010	28.9N	078.5W	1343	19.6	23.3	1.9	3.6	13 05	15.0	N	28.2	13 03	1017.5
41016	24.6N	076.5W	0672	22.1	24.3	0.6	1.4	03 06	13.2	NE	25.3	10 06	1017.2
42001	25.9N	089.7W	0669	20.2	21.8	1.4	3.2	07 09	13.6	NE	27.6	06 16	1018.4
42002	25.9N	093.6W	0672	20.0	21.0	1.4	3.2	15 10	12.5	NE	26.8	15 06	1017.9
42003	25.9N	085.9W	0672	21.2	25.8	1.6	4.2	07 21	16.7	NE	30.5	07 19	1018.0
42007	30.1N	088.8W	0669	13.0	15.0				13.3	N	27.6	12 09	1018.9
42019	27.9N	095.0W	0672	18.4	21.2	1.5	4.0	15 21	13.8	NE	27.2	16 08	1017.9
42020	27.0N	096.5W	0670	19.6	21.4	1.5	3.5	15 17	13.6	SE	28.6	04 02	1017.3
44005	42.6N	068.6W	0670	-1.5	4.4	2.5	8.1	28 19	17.9	N	35.6	28 18	1014.8
44007	43.5N	070.1W	0672	-5.3	2.4	1.4	5.1	13 14	15.6	N	35.2	02 03	1017.5
44013	42.4N	070.8W	0669	-3.3	2.5	1.2	5.2	13 07	16.1	N	32.4	17 14	1016.6
44014	36.6N	074.8W	0669	5.5	8.4	1.8	5.6	27 13	15.8	NW	33.0	27 13	1018.0
44025	40.3N	073.2W	0671	0.6	4.1	1.5	5.0	12 15	16.3	NW	31.7	12 17	1017.6
46001	56.3N	148.2W	0619	2.2	3.9	3.1	5.7	03 19	14.2	S	30.7	03 10	1006.8
46002	42.5N	130.3W	0637	9.6	10.9	3.5	8.4	05 02	16.0	SE	36.7	04 20	1011.4
46003	51.9N	155.9W	0194	0.3	3.7	4.3	8.6	03 22	20.8	N	36.1	03 10	1006.2
46005	46.1N	131.0W	0626	8.3	9.5	3.3	9.6	05 05	15.1	SE	35.6	05 05	1011.7
46006	40.9N	137.5W	0639	11.1	12.1	3.8	7.5	03 11	18.2	S	34.8	02 05	1010.4
46012	37.4N	122.7W	0452	12.6	13.2	2.6	4.6	05 12	11.6	SE	32.1	17 22	1013.5
46013	38.2N	123.3W	0640	11.6	12.4	2.7	5.7	20 00	12.3	NW	32.1	19 23	1013.4
46014	39.2N	124.0W	0069	12.4	11.9	2.0	2.8	03 23	10.1	SE	22.9	04 00	1019.9
46022	40.8N	124.5W	0632	10.3	11.5	2.6	5.2	05 12	11.4	S	29.1	05 00	1013.1
46023	34.3N	120.7W	0636	13.5	14.1	2.5	4.1	08 21	11.9	NW	28.2	18 09	1015.3
46025	33.8N	119.1W	0639	13.9	14.9	1.7	3.5	10 01	9.4	W	26.0	08 05	1015.9
46026	37.8N	122.7W	0632	11.4	12.0	2.1	4.4	20 00	12.0	W	34.4	19 22	1014.3
46027	41.8N	124.4W	0621	9.5	10.6	2.3	4.2	04 11					1012.8
46028	35.8N	121.9W	0637	13.0					12.2	NW	33.2	07 22	1015.0
46029	46.2N	124.2W	0636	7.1	9.3	2.2	4.6	05 23	12.3	E	25.7	17 14	1015.2
46030	40.4N	124.5W	0633	10.5	11.5	2.0	4.5	05 15	13.1	SE	30.3	10 22	1012.6
46035	57.0N	177.7W	0634	0.1	1.6	3.3	8.6	03 17	18.0	E	37.5	03 20	994.8
46041	47.4N	124.5W	0627	6.8	8.2	1.9	3.4	04 15	8.6	SE	21.6	04 18	1015.1
46042	36.8N	122.4W	0637	12.0		2.7	4.9	08 03	12.2	NW	36.5	05 09	1014.8
46045	33.8N	118.5W	0633	13.9	15.0	1.3	2.6	25 03	8.0	W	29.5	08 06	1015.5
46047	32.7N	119.6W	0640	14.2	15.0	2.4	4.2	09 19	11.8	NW	26.8	08 00	1016.5
46048	32.9N	117.9W	0636	14.5	15.5	1.4	3.4	18 22	10.0	W	32.6	08 05	1016.0
46050	44.6N	124.5W	0641	8.3	10.1	2.3	4.7	04 16	11.7	E	24.7	21 10	1014.5
46051	34.5N	120.7W	0633	13.4	14.3	2.5	4.1	09 19	11.3	NW	32.3	08 03	1015.6
51001	23.4N	162.3W	0633	21.6	23.1	3.2	8.1	06 02	10.4	E	25.6	01 00	1017.5

BUOY	LAT	LONG	OBS	MEAN AIR TP (C)	MEAN SEA TP (C)	MEAN SIG WAVE HT (M)	MAX SIG WAVE HT (M)	MAX SIG WAVE HT (DA/HR)	SCALAR MEAN WIND SPEED (KNOTS)	PREV WIND (DIR)	MAX WIND (KTS)	MAX WIND (DA HR)	MEAN PRESS (MB)
1004	17.4N	152.5W	0639	23.2	24.7	2.9	7.0	06/21	14.0	NE	23.5	25 20	1014.7
51026	21.4N	157.0W	0637	21.8	22.9	2.8	6.8	06/17	13.8	E	24.5	01 09	1016.5
52009	13.7N	144.7E	0415		25.1	2.0	4.0	03 09	14.8	NE	22.3	03 07	1012.4
91222	18.1N	145.8E	0649	24.5					6.8	NE	16.0	17/01	1014.8
91251	11.4N	162.4E	0634	25.9					16.4	NE	30.4	28/21	1011.7
91328	8.6N	149.7E	0628	27.0					10.4	NE	21.2	28 19	1010.1
91355	5.4N	163.0E	0628	26.8					8.8	NE	21.3	07/13	1008.7
91377	6.1N	172.1E	0636	26.5									1008.8
ABAN6	44.3N	075.9W	0670	-11.0	0.1				4.2	N	17.2	21/23	1020.7
ALSN6	40.5N	073.8W	0672	-0.8	4.9	1.1	3.6	12/15	18.6	NW	37.6	17/12	1018.6
BURL1	28.9N	089.4W	0604	13.8					15.6	N	34.9	25 22	1019.6
BUSL1	27.9N	090.9W	0671	18.6	21.1				14.7	NE	30.7	21 15	1017.7
BUZM3	41.4N	071.0W	0672	-2.0					18.0	NW	40.9	17/02	1016.2
CARO3	43.3N	124.4W	0641	8.3					10.2	SE	35.5	21/10	1012.8
CHLV2	36.9N	075.7W	0671	3.9	5.7	1.4	4.1	27/12	17.5	N	40.7	01/22	1018.7
CLKN7	34.6N	076.5W	0672	7.8					13.1	N	26.6	07 22	1018.5
CSBF1	29.7N	085.4W	0639	13.2					7.6	N	22.3	12/23	1018.4
DBLN6	42.5N	079.4W	0421	-5.7					14.1	W	33.6	22 10	1017.3
DESW1	47.7N	124.5W	0641	6.5					10.2	SE	28.0	05/15	1015.1
DISW3	47.1N	090.7W	0672	-6.4					13.2	SW	30.7	11/08	1021.5
DPIA1	30.3N	088.1W	0639	12.3	13.3				12.2	N	28.4	26/03	1018.8
DRYF1	24.6N	082.9W	0671	21.0	22.6				13.2	E	25.0	25 01	1017.6
DSLN7	35.2N	075.3W	0415	8.7	10.3	2.9	4.9	02 13	19.2	N	42.4	16/19	1017.8
FBIS1	32.7N	079.9W	0672	9.7					10.0	NE	32.7	07/18	1018.6
FFIA2	57.3N	133.6W	0636	2.5					15.3	N	35.5	03 11	1013.7
FPSN7	33.5N	077.6W	0621	11.9	16.2				18.7	N	39.2	08/02	1017.0
FWYF1	25.6N	080.1W	0672	20.8	23.4								1017.8
GDIL1	29.3N	090.0W	0639	14.2	15.9				12.2	NE	26.5	12/16	1018.9
GLLN6	43.9N	076.5W	0672	-8.4					12.8	NE	29.6	22/15	1019.6
IOSN3	43.0N	070.6W	0671	-4.6					17.3	NW	40.0	17/15	1016.7
LONF1	24.9N	080.9W	0671	20.6	21.3				11.0	NW	23.4	19/07	1017.6
MDRM1	44.0N	068.1W	0654	-5.0					19.8	NW	43.0	17/02	1015.7
MISM1	43.8N	068.9W	0670	-5.1					19.1	NW	45.0	17/03	1016.3
MLRF1	25.0N	080.4W	0672	21.2	23.4				14.2	N	29.5	23 06	1017.1
NWPO3	44.6N	124.1W	0639	6.7					9.7	E	25.9	21/01	1014.1
PILM4	48.2N	088.4W	0671	-8.8					13.6	N	35.6	02 16	1021.3
PTAC1	39.0N	123.7W	0638	10.2					10.7	SE	62.0	20/00	1014.0
PTAT2	27.8N	097.1W	0636	15.5	16.0				11.3	N	28.1	03 23	1017.7
PTGC1	34.6N	120.7W	0637	13.0					11.9	S	41.7	08 04	1015.1
ROAM4	47.9N	089.3W	0397	-6.8					15.6	NE	36.0	02/14	1023.0
SANF1	24.5N	081.9W	0671	21.1	23.0				13.7	NE	28.0	19/02	1017.3
SAUF1	29.9N	081.3W	0671	12.8					9.7	N	26.8	02 12	1018.6
SBIO1	41.6N	082.8W	0633	-3.8					11.1	SW	27.2	01 04	1019.7
SGNW3	43.8N	087.7W	0671	-5.1	0.4				12.4	W	30.9	21 18	1021.0
SISW1	48.3N	122.9W	0637	5.5					8.6	E	35.9	15/06	1017.0
SMKF1	24.6N	081.1W	0664	21.1	22.7				14.3	SE	29.5	03/10	1017.6
SPGF1	26.7N	079.0W	0671	20.6	23.5				9.3	E	23.2	12/13	1018.7
SRST2	29.7N	094.1W	0567	13.0					10.1	NE	20.9	15 17	1018.9
STDM4	47.2N	087.2W	0671	-7.1					17.8	W	35.7	07 20	1020.0
SUPN6	44.5N	075.8W	0670	-11.7	0.2				7.8	N	23.1	06 00	1019.0
SVLS1	32.0N	080.7W	0665	10.6	12.0	0.9	3.1	07 16	15.2	NE	42.6	07/15	1018.3
TTIW1	48.4N	124.7W	0637	6.4					15.2	NE	43.7	04/17	1016.1
VENF1	27.1N	082.5W	0637	16.4	18.1				10.5	NE	26.5	19/01	1018.6
WPOW1	47.7N	122.4W	0640	5.9					6.3	N	19.7	15/22	1015.9
March													
32302	18.0S	085.1W	0726	22.9	23.8	2.0	3.9	22/00	11.2	SE	18.5	05 08	1013.7
41001	34.7N	072.7W	0139	17.9	19.6	1.5	2.7	30 10	12.7	NW	22.9	30 08	1011.2
41002	32.3N	075.2W	0735	17.7	21.7	2.7	15.7	14/03	17.4	W	48.8	13/21	1017.1
41004	32.5N	079.1W	0732	14.8	17.5				15.2	W	48.4	13/17	1017.8
41006	29.3N	077.4W	0733	20.1	22.3	2.3	10.0	13 23	16.4	W	43.9	13/18	1017.1
41009	28.5N	080.2W	1468	18.7	20.2	1.3	4.9	19/04	15.0	W	44.5	13/15	1017.3
41010	28.9N	078.5W	1465	20.1	22.7	2.2	8.3	13/20	16.0	W	43.1	13/17	1017.6
41016	24.6N	076.5W	0735	22.5	24.0	0.6	2.2	17/03	12.2	E	30.2	13/14	1017.3
42001	25.9N	089.7W	0732	20.3	21.4	1.4	9.1	13/11	11.9	SE	46.4	13/01	1016.7
42002	25.9N	093.6W	0734	20.1	21.0	1.3	7.8	13/09	11.3	SE	53.0	12 19	1016.8
42003	25.9N	085.9W	0737	21.8	25.3	1.5	9.2	13/14	15.2	E	48.0	13/11	1017.4
42007	30.1N	088.8W	0730	14.6	15.8				13.4	E	43.7	13 09	1017.4
42019	27.9N	095.0W	0727	19.2	21.4	1.4	5.8	12 19	13.3	SE	41.2	12 15	1016.4
42020	27.0N	096.5W	0724	20.0	21.6	1.4	6.1	13/04	12.4	E	36.5	12/14	1016.1
444005	42.6N	068.6W	0734	-1.9	3.7	2.4	9.2	14/14	30.6	N	33.6	01 00	1015.9
44007	43.5N	070.1W	0729	-0.1	1.3	1.5	7.0	14/03	13.6	N	46.6	13 23	1018.2
44013	42.4N	070.8W	0728	0.9	1.6	1.3	6.1	06/05	14.2	N	49.9	13 22	1017.3
44014	36.6N	074.8W	0735	6.7	7.0	1.4	7.8	13/19	11.9	N	41.8	13 22	1017.7
44025	40.3N	073.2W	0730	2.8	3.1	1.3	7.3	14 03	13.3	W	41.8	13 19	1017.6
45007	42.8N	087.1W	0038	4.1	2.9	0.1	0.2	29/23	9.0	NE	27.6	31 23	1010.8
46001	56.3N	148.2W	0728	3.3	4.0	3.0	7.6	03 18	15.0	SE	34.0	03 14	1003.8
46002	42.5N	130.3W	0730	10.7	11.0	3.2	7.4	31/22	12.2	S	32.8	31 20	1015.4

BUOY	LAT	LONG	OBS	MEAN AIR TP (C)	MEAN SEA TP (C)	MEAN SIG WAVE HT (M)	MAX SIG WAVE HT (M)	MAX SIG WAVE HT (DA HR)	SCALAR MEAN WIND SPEED (KNOTS)	PREV WIND (DIR)	MAX WIND (KTS)	MAX WIND (DA HR)	MEAN PRESS (MB)
46005	46.1N	131.0W	0343	9.0	9.3	2.8	7.0	04 21	14.0	NE	28.6	03 03	1014.2
46006	40.9N	137.5W	0729	11.7	11.9	3.9	9.0	02 23	16.7	S	36.7	02 20	1013.6
46013	38.2N	123.3W	0730	12.2	12.7	2.6	6.3	23 23	10.9	NW	27.2	29 01	1018.9
46022	40.8N	124.5W	0686	11.1	11.6	2.6	5.7	23 17	10.1	S	29.5	17 06	1019.2
46023	34.3N	120.7W	0729	13.4	13.9	2.5	4.9	04 13	13.7	NW	27.0	21 08	1018.4
46025	33.8N	119.1W	0729	14.6	15.4	1.4	3.1	04 19	7.3	W	28.0	27 01	1017.9
46026	37.8N	122.7W	0726	12.3	13.1	1.9	4.1	03 23	10.5	NW	26.4	17 08	1019.6
46027	41.8N	124.4W	0670	10.7	11.2	2.5	6.0	23 15					1018.4
46028	35.8N	121.9W	0730	13.2					12.2	NW	27.0	20 20	1019.5
46029	46.2N	124.2W	0072	9.3	9.7	3.2	4.6	03 23	15.5	S	25.4	01 11	1018.4
46030	40.4N	124.5W	0733	11.2	11.6	2.0	5.7	23 18	12.0	SE	30.5	31 18	1018.6
46035	57.0N	177.7W	0731	-0.8	1.4	2.5	9.1	11 11	13.1	E	36.1	11 05	999.3
46041	47.4N	124.5W	0719	8.3	9.0	2.4	6.4	23 12	10.8	SE	31.1	04 08	1017.2
46042	36.8N	122.4W	0733	12.6		2.4	5.3	24 01	10.5	NW	24.9	26 06	1019.9
46045	33.8N	118.5W	0730	14.8	15.5	1.0	3.0	27 07	6.1	SW	23.3	27 02	1017.4
46047	32.7N	119.6W	0736	14.3	15.2	2.4	4.5	24 12	14.1	NW	29.7	19 00	1018.9
46048	32.9N	117.9W	0733	15.1	16.4	1.3	3.0	27 08	7.8	W	27.2	26 03	1017.7
46050	44.6N	124.5W	0726	9.9	10.2	2.6	6.4	23 15	11.4	S	28.0	22 18	1018.3
46051	34.5N	120.7W	0716	13.3	13.8	2.4	4.6	04 09	12.2	NW	24.7	21 07	1018.9
51001	23.4N	162.3W	0731	21.5	22.9	2.6	5.3	14 21	11.1	E	31.6	14 14	1020.4
51003	19.3N	160.8W	0732	23.2	24.4	2.7	4.9	15 09	13.7	NE	21.8	02 09	1017.1
51004	17.4N	152.5W	0726	23.4	24.3	2.7	4.9	15 19	15.6	E	23.5	27 16	1015.8
51026	21.4N	157.0W	0711	21.9	23.0	2.5	5.0	14 21	14.6	NE	26.4	15 00	1018.6
52009	13.7N	144.7E	0366		24.9	1.8	3.1	14 07	13.9	E	21.4	14 07	1012.1
91222	18.1N	145.8E	0699	24.7					6.2	E	19.7	12 00	1013.9
91251	11.4N	162.4E	0689	26.3					17.7	E	25.1	03 21	1011.4
91328	8.6N	149.7E	0688	26.9					9.8	NE	19.0	01 02	1009.6
91338	5.3N	153.7E	0532	27.1					4.3	N	16.8	26 09	1008.5
91343	7.6N	155.2E	0695	26.9					10.7	NE	24.1	25 11	1009.4
91352	6.2N	160.7E	0690	26.9					10.7	NE	24.7	12 11	1009.5
91355	5.4N	163.0E	0691	26.6					8.7	NE	27.1	09 20	1008.4
91377	6.1N	172.1E	0733	26.8									1009.2
ABAN6	44.3N	075.9W	0735	-2.4	0.3				4.9	N	24.3	14 00	1020.0
ALSN6	40.5N	073.8W	0735	2.8	8.5	1.1	5.7	13 21	16.5	NW	61.5	13 21	1018.4
BURL1	28.9N	089.4W	0730	14.7					14.1	NE	51.2	13 01	1018.6
BUSL1	27.9N	090.9W	0657	19.5	21.3				12.6	E	47.6	12 22	1016.7
BUZM3	41.4N	071.0W	0735	1.5					16.9	N	55.8	13 22	1016.9
CARO3	43.3N	124.4W	0732	10.6					10.4	S	32.8	17 00	1017.5
CHLV2	36.9N	075.7W	0735	6.1	4.7	1.2	4.9	14 01	15.4	NE	54.0	14 00	1017.8
CLKN7	34.6N	076.5W	0729	10.6					13.4	NE	48.9	13 20	1017.9
CSBF1	29.7N	085.4W	0727	14.9					8.4	E	42.4	13 17	1017.5
DBLN6	42.5N	079.4W	0729	-1.5					10.9	NE	40.2	13 21	1018.8
DESW1	47.7N	124.5W	0733	8.1					12.8	SE	49.7	04 10	1017.2
DISW3	47.1N	090.7W	0725	-2.4					10.4	NE	41.7	31 15	1020.0
DPIA1	30.3N	088.1W	0731	14.1	14.8				12.4	SW	43.5	13 02	1017.4
DRYF1	24.6N	082.9W	0734	21.1	22.1				11.4	NE	48.2	13 07	1017.3
DSLN7	35.2N	075.3W	0169	12.2					13.8	N	32.9	27 18	1013.4
FBIS1	32.7N	079.9W	0716	11.9					10.9	SW	46.8	13 14	1017.3
FFIA2	57.3N	133.6W	0733	3.7					13.1	N	39.4	21 22	1011.6
FPSN7	33.5N	077.6W	0617	14.5	14.5				18.7	SW	60.8	13 22	1016.0
FWYF1	25.6N	080.1W	0163	21.2	22.8								1017.0
GDIL1	29.3N	090.0W	0729	15.7	17.0				11.7	E	44.9	13 01	1017.3
GLLN6	43.9N	076.5W	0734	-1.9					11.8	NE	42.2	14 08	1019.1
IOSN3	43.0N	070.6W	0734	0.3					15.7	NE	48.9	14 00	1017.4
LONF1	24.9N	080.9W	0734	21.6	22.6				11.3	E	38.2	13 17	1017.3
MDRM1	44.0N	068.1W	0735	-0.2					17.7	NW	52.0	14 02	1016.9
MISM1	43.8N	068.9W	0736	-0.3					17.4	NE	62.5	14 01	1017.3
MLRF1	25.0N	080.4W	0732	21.8	22.9				12.9	E	41.5	13 20	1016.8
NWPO3	44.6N	124.1W	0731	9.6					9.6	E	30.5	04 15	1018.0
PILM4	48.2N	088.4W	0732	-3.5					10.8	N	33.9	17 02	1020.0
PTAC1	39.0N	123.7W	0728	11.4					8.9	N	27.2	16 23	1019.9
PTAT2	27.8N	097.1W	0731	17.3	17.8				10.8	E	37.7	12 12	1016.1
PTGC1	34.6N	120.7W	0726	13.0					13.7	N	30.0	21 11	1018.5
SANF1	24.5N	081.9W	0735	21.5	22.6				10.8	NE	30.0	13 06	1016.9
SAUF1	29.9N	081.3W	0735	15.3					11.0	W	36.4	13 06	1017.8
SBIO1	41.6N	082.8W	0696	-0.4					10.3	NE	34.9	14 05	1017.8
SGNW3	43.8N	087.7W	0735						11.5	N	32.2	31 21	1018.6
SISW1	48.3N	122.9W	0731	8.2					10.7	SE	45.1	04 10	1018.1
SMKF1	24.6N	081.1W	0733	21.8	22.8				13.5	E	47.5	13 09	1017.5
SPGF1	26.7N	079.0W	0734	20.9	23.9				9.0	E	28.7	14 04	1018.8
SRST2	29.7N	094.1W	0732	15.0					10.6	SE	29.3	12 22	1017.4
STDM4	47.2N	087.2W	0724	-2.8					13.9	N	38.9	16 22	1018.9
SUPN6	44.5N	075.8W	0730	-2.9	0.2				8.6	N	39.7	14 04	1018.4
SVLS1	32.0N	080.7W	0734	12.6	12.5	1.0	4.5	13 15	16.2	NE	57.5	13 15	1017.3
TTIW1	48.4N	124.7W	0733	8.1					16.1	E	44.1	04 10	1017.3
VENF1	27.1N	082.5W	0730	17.7	18.8				10.1	NE	42.1	13 17	1018.1
WPOW1	47.7N	122.4W	0713	8.5					7.9	N	27.8	20 13	1017.5

January 1992

Wave observations are taken each hour during a 20–minute averaging period, with a sample taken every 0.67 seconds. The significant wave height is defined as the average height of the highest one–third of the waves during the average period each hour. The maximum significant wave height is the highest of those values for that month. At most stations, air temperature, water temperature, wind speed and direction are sampled once per second during an 8.0–minute averaging period each hour (moored buoys) and a 2.0–minute averaging period for fixed stations (C–MAN). Contact NDBC Data Systems Division, Bldg 1100, SSC, Mississippi 39529 or phone (601) 688–2838 for more details.

BUOY	LAT	LONG	OBS	MEAN AIR TP (C)	MEAN SEA TP (C)	MEAN SIG WAVE HT (M)	MAX SIG WAVE HT (M)	MAX SIG WAVE HT (DA/HR)	SCALAR MEAN WIND SPEED (KNOTS)	PREV WIND (DIR)	MAX WIND (KTS)	MAX WIND (DA/HR)	MEAN PRESS (MB)
January													
32302	18.0S	085.1W	0741	21.5	21.9	1.9	3.4	25/16	10.1	SE	18.7	12/23	1014.7
41001	34.9N	073.0W	0738	14.7	20.6	2.9	10.1	04/04	17.1	NW	43.3	04/03	1014.9
41002	32.3N	075.2W	0019	19.1	22.1	3.1	4.3	03/09	20.6	E	26.2	03/06	1020.9
41006	29.3N	077.4W	0067	21.4	22.3	1.8	3.2	31/23	13.2	W	23.7	31/19	1015.2
41008	30.7N	081.1W	0740	12.3	13.5	1.0	2.8	01/02	10.8	NW	25.1	19/17	1018.4
41009	28.5N	080.2W	1478	18.3	22.2	1.3	4.0	02/17	12.3	NW	25.1	20/14	1018.4
41010	28.9N	078.5W	0644	20.4	23.5	2.1	4.4	03/22	16.5	NW	30.1	14/15	1014.9
42001	25.9N	089.7W	0740	19.8	22.3	1.3	4.1	14/15	13.8	NE	25.1	10/17	1018.1
42002	25.9N	093.6W	0741	19.6	21.7	1.6	4.1	14/07	15.6	N	29.1	10/13	1018.3
42003	25.9N	085.9W	0740	21.0	25.5	1.2	2.9	14/20	13.4	N	25.3	14/09	1018.4
44005	42.6N	068.6W	0369	-1.2	5.5	1.8	7.4	15/11	17.2	W	36.9	24/04	1013.1
44007	43.5N	070.1W	0605	-3.1	5.1	0.9	4.6	05/09	13.5	W	36.9	15/11	1014.0
44008	40.5N	069.4W	0739	3.1	6.4	2.2	7.3	24/10	17.1	NW	40.2	15/08	1014.3
44009	38.5N	074.7W	0741	4.9	7.2	1.2	7.6	04/12	15.8	NW	42.4	16/14	1015.9
44011	41.1N	066.6W	0740	2.6	6.0	2.7	8.8	24/18	16.2	W	35.6	19/05	1013.1
44012	38.8N	074.6W	0741	4.2	6.4	1.2	8.5	04/14	16.0	W	44.9	16/14	1015.6
44013	42.4N	070.8W	0740	-0.3	4.4	0.7	3.2	05/03	15.7	W	39.8	15/07	1013.3
44014	36.6N	074.8W	0740	8.4	10.7	1.8	7.5	04/10	14.6	NW	33.6	04/10	1018.0
44025	40.3N	073.2W	0706	3.8	6.9	1.4	6.3	04/16	15.7	NW	35.0	16/15	1015.2
45002	45.3N	086.4W	0738	-2.8	4.5	1.0	2.9	24/08					1014.8
46001	56.3N	148.3W	0740	3.6	4.5	3.8	9.3	17/10	16.6	SE	36.3	16/02	989.3
46002	42.5N	130.3W	0581	11.9	11.7	4.0	9.0	31/11					1014.1
46003	51.9N	155.9W	0741	3.5	4.4	4.1	8.2	01/01					985.8
46005	46.1N	131.0W	0739	10.2	10.8	4.1	7.9	25/14	17.0	S	35.9	29/20	1008.8
46012	37.4N	122.7W	0739	12.0	12.7	2.7	5.2	05/18	10.4	N	30.9	05/05	1019.2
46013	38.2N	123.3W	0739	10.4	12.5	2.9	5.8	29/15	11.7	E	34.4	05/04	1019.5
46014	39.2N	124.0W	0372	10.6	12.1	3.2	5.8	05/11	11.8	NW	39.1	05/04	1017.9
46022	40.8N	124.5W	0738	10.5	10.8	3.3	6.5	26/02	12.0	S	36.7	05/10	1018.2
46023	34.3N	120.7W	0740	13.6	13.7	2.8	5.2	29/23	12.3	NW	27.4	11/18	1017.0
46025	33.8N	119.1W	0740	14.3	14.3	1.4	3.1	30/03	6.8	NW	25.8	07/23	1016.5
46026	37.8N	122.7W	0738	9.9	11.5	2.2	4.3	05/16	12.6	NE	33.2	05/05	1019.2
46027	41.8N	124.4W	0734	10.2	10.4	2.9	5.5	05/13	11.1	SE	32.8	28/02	1017.8
46029	46.2N	124.2W	0736	9.2	9.9	3.4	8.8	31/18	15.5	S	37.1	31/17	1016.1
46035	57.0N	177.7W	0738	-0.8	2.8	3.0	9.4	12/09	16.0	E	35.3	12/02	990.7
46040	44.8N	124.3W	0738	9.7		3.5	7.8	31/18					1016.1
46041	47.4N	124.5W	0734	8.5	8.9	3.3	9.5	31/23	15.5	SE	38.7	31/20	1014.3
46042	36.8N	122.4W	0741	12.1		3.0	5.2	06/21	10.6	NW	30.7	05/05	1018.9
46045	33.8N	118.5W	0740	14.0	14.8	1.0	2.6	07/07	5.1	NE	22.2	05/18	1016.6
46047	32.7N	119.6W	0704	14.1	14.4	2.6	5.2	30/04	12.2	NW	36.3	12/02	1016.5
46048	32.9N	117.9W	0741	14.7	15.1	1.3	2.8	06/15	7.6	NW	24.5	08/06	1016.3
46050	44.6N	124.5W	0735	9.9	9.9	3.5	7.5	31/17	12.7	S	35.2	25/06	1015.6
46A47	32.7N	119.6W	0700	13.7	14.0	2.6	5.1	30/01	11.7	NW	35.4	12/03	1016.1
51001	23.4N	162.3W	0739	22.3	24.3	3.4	7.2	27/20	11.8	SW	24.2	23/12	1015.9
51002	17.2N	157.8W	0741	23.9		2.7	5.7	15/20	13.2	E	28.9	15/18	1014.8
51003	19.3N	160.8W	0246	24.1	25.4	3.0	5.1	15/06	9.9	NE	24.9	15/03	1015.0
51004	17.4N	152.5W	0246	23.6	24.3	2.7	4.3	29/00	12.8	E	23.0	03/06	1014.7
52009	13.7N	144.7E	0617	26.4	26.5	2.3	4.3	11/21	15.2	NE	24.5	05/16	1012.8
91343	7.6N	155.2E	0740	26.7					11.7	NE	24.4	31/18	1011.0
91353	6.2N	160.7E	0740	26.9					12.2	NE	54.9	09/05	1007.6
91365	8.9N	165.8E	0170	26.9					17.5	NE	30.6	07/23	1007.8
91377	6.1N	172.1E	0739	26.5					10.5	NE	42.8	07/08	1009.3
ALSN6	40.5N	073.8W	0737	2.2	6.0	1.0	4.7	04/17	17.5	NW	44.9	15/04	1015.9
BURL1	28.9N	089.4W	0730	12.1					13.7	N	35.3	19/01	1019.4
BUZM3	41.4N	071.0W	0739	0.8									
CSBF1	29.7N	085.4W	0740	11.7					6.3	NW	26.3	14/10	1019.4
DBLN6	42.5N	079.4W	0741	-1.3					14.6	W	42.6	24/11	1014.9
DESW1	47.7N	124.5W	0739	8.1									1014.6
DISW3	47.1N	090.7W	0739	-5.5					12.7	SW	35.2	23/17	1015.8
DPIA1	30.3N	088.1W	0738	11.0	12.2				10.8	N	30.9	19/08	1019.5
DSLN7	35.2N	075.3W	0676	11.1		2.0	6.0	03/22	19.6	NW	55.4	23/21	1016.2
FBIS1	32.7N	079.9W	0737	9.9					8.7	W	23.3	14/09	1017.9
FPIA2	57.3N	133.6W	0741	4.5					15.8	SE	40.3	19/10	1002.3

NDBC Station Data Summary

BUOY	LAT	LONG	OBS	MEAN AIR TP (C)	MEAN SEA TP (C)	MEAN SIG WAVE HT (M)	MAX SIG WAVE HT (M)	MAX SIG WAVE HT (DA/HR)	SCALAR MEAN WIND SPEED (KNOTS)	PREV WIND (DIR)	MAX WIND (KTS)	MAX WIND (DA HR)	MEAN PRESS (MB)
FPSN7	33.5N	077.6W	0740	12.9	18.1				18.3	W	40.9	14 14	1016.9
FWYF1	25.6N	080.1W	0739	20.3	22.7				14.4	NW	28.3	14 18	1017.7
GBCL1	27.8N	093.1W	0468	15.5	21.3				15.7	NE	31.7	27 04	1021.5
GDIL1	29.3N	090.0W	0735	12.0	13.6				11.3	NE	37.0	19 01	1019.4
GLLN6	43.9N	076.5W	0741	-4.1					13.6	NW	38.2	24 12	1014.8
IOSN3	43.0N	070.6W	0713	-1.9					16.3	W	42.6	24 03	1012.8
KOSP2	5.4N	163.0E	0740	27.0					10.1	NE	39.9	08 20	1009.5
MDRM1	44.0N	068.1W	0740	-2.7					18.8	NW	49.0	24 05	1012.8
MISM1	43.8N	068.9W	0675	-2.3					18.9	NW	52.5	24 04	1013.0
MLRF1	25.0N	080.4W	0739	20.8	23.5				13.2	N	23.4	16 08	1017.2
MPCL1	29.4N	088.6W	0731	14.4	18.6	1.3	3.7	19/06	14.3	NW	42.4	19 01	1019.7
NWPO3	44.6N	124.1W	0738	9.0									
PTAC1	39.0N	123.7W	0739	9.6					8.8	S	40.5	05 04	1019.4
PTAT2	27.8N	097.1W	0742	12.8	13.8				9.7	N	26.3	13 19	1019.3
PTGC1	34.6N	120.7W	0738	13.2					10.6	N	37.0	11 18	1017.2
ROAM4	47.9N	089.3W	0741	-6.7	2.3								1015.5
SANF1	24.5N	081.9W	0740	20.7	23.2				12.3	NE	26.5	24 23	1017.4
SAUF1	29.9N	081.3W	0740	12.6	14.2				9.2	N	31.4	19 20	1018.2
SBIO1	41.6N	082.8W	0741	-1.6					13.8	SW	43.6	14 11	1016.5
SGNW3	43.8N	087.7W	0741	-2.8					11.9	W	31.1	14 10	1015.8
SISW1	48.3N	122.9W	0662	7.6					15.9	SE	47.3	02 01	1014.6
SMKF1	24.6N	081.1W	0734	20.7	22.8				13.9	N	25.5	20 14	1017.6
SPGF1	26.7N	079.0W	0740	20.5	23.4				9.2	E	29.6	04 15	1017.3
SRST2	29.7N	094.1W	0739	10.7					8.6	N	27.1	13 19	1019.7
STDM4	47.2N	087.2W	0738	-4.7									
TTIW1	48.4N	124.7W	0739	7.8					19.5	SE	57.2	31 23	1014.1
VENF1	27.1N	082.5W	0741	15.3	16.8				9.2	NE	25.5	04 10	1018.4

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